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**SOUTHWEST RESEARCH INSTITUTE  
BIOMEDICAL APPLICATIONS TEAM**

*Assistance to NASA in Biomedical Areas  
of the Technology Utilization Program*

(NASA-CR-138502) SOUTHWEST RESEARCH INSTITUTE ASSISTANCE TO NASA IN  
BIOMEDICAL AREAS OF THE TECHNOLOGY  
UTILIZATION PROGRAM (Southwest Research  
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*FINAL REPORT*

**AUGUST 1972 - NOVEMBER 1973  
NASA CONTRACT NO. NASW-1867  
SWRI PROJECT NO. 13- 538**



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SOUTHWEST RESEARCH INSTITUTE  
ASSISTANCE TO NASA IN BIOMEDICAL  
AREAS OF THE TECHNOLOGY  
UTILIZATION PROGRAM

FINAL REPORT

25 August 1972 - 15 November 1973

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SwRI Project No. 13-2538

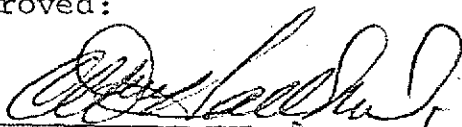
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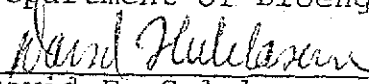
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SwRI NASA Biomedical Applications Team

## PREFACE

This Report covers the activities of the NASA Biomedical Applications Team at Southwest Research Institute between 25 August, 1972 and 15 November, 1973 in the performance of NASA Contract NASW-1867. This work was performed in the Department of Bioengineering at Southwest Research Institute under the direction of David F. Culclasure, Ph.D., Team Manager. Other members of the team who participated in the program during the reporting period were as follows:

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Linda L. Eckhardt  
Dennis C. Jamvold  
Charles J. Laenger, Sr.  
Samuel R. McFarland  
John L. Sigmon  
Robert L. Wilbur

Other staff personnel at Southwest Research Institute provided assistance as needed.

Technical consultants who actively contributed to the program were as follows:

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Jack Johnson, Veterans Administration Hospital,  
Little Rock, Arkansas  
Hermann Rudenberg, Ph.D., University of Texas Medical  
Branch, Galveston, Texas  
Frank DeSautels, Brooke General Hospital, Ft. Sam  
Houston, Texas  
Sam Schiflett, Texas Tech University, Lubbock, Texas

Names and addresses of commercial products and services are included in this report for information dissemination only. This does not constitute endorsement of these sources by either the National Aeronautics and Space Administration or Southwest Research Institute.

## ABSTRACT

The NASA Biomedical Applications Team at Southwest Research Institute serves as an information and technology interface between NASA and the biomedical community. In an ongoing experimental program, a team of multi-disciplinary scientists and engineers applies aerospace technology to biomedical research and health problems. The Southwest Research Institute Biomedical Applications Team is currently staffed by:

David F. Culclasure, Ph.D.  
Jean M. Carter  
Charles B. Dreyer  
Charles J. Laenger, Sr.  
Samuel F. McFarland  
John L. Sigmon  
Robert L. Wilbur

The following 60 medical institutions participated in the Biomedical Applications Program at Southwest Research Institute during this report period:

- \* M. D. Anderson Hospital, Houston, Texas
- \* Arkansas Enterprises for the Blind, Inc., Little Rock, Arkansas
- Baylor University Medical Center, Jonsson Hospital, Dallas, Texas
- Baylor College of Medicine, Houston, Texas
- \* Brooke General Hospital, Ft. Sam Houston, Texas
- \* Callier Hearing and Speech Center, Dallas, Texas
- Cerebral Palsy Treatment Center, San Antonio, Texas
- \* Children's Convalescent Hospital, Oklahoma City, Oklahoma
- Children's Hospital of Los Angeles, Los Angeles, California
- \* Craig Rehabilitation Hospital, Englewood, Colorado
- \* Fitzsimmons General Hospital, Denver, Colorado



- \* General Rose Hospital, Denver, Colorado
- Hollywood Presbyterian Hospital, Los Angeles, California
- Hot Springs Rehabilitation Center, Little Rock, Arkansas
- Loma Linda Medical Center, Loma Linda, California
- \* Louisiana State University Medical School, New Orleans, Louisiana
- Mercy Hospital, Birmingham, Alabama
- Methodist Hospital, Houston, Texas
- Northwestern University Medical School, Chicago, Illinois
- \* Pacific State Hospital, Pomona, California
- \* Rancho Los Amigos Hospital, Downey, California
- \* Rosewood General Hospital, Houston, Texas
- St. Joseph's Hospital, Phoenix, Arizona
- \* Scott and White Hospital and Clinic, Temple, Texas
- Southwest Research Institute, San Antonio, Texas
- Texas A&M University, College Station, Texas
- Texas Association for Retarded Children, Austin, Texas
- Texas Children's Hospital, Houston, Texas
- \* Texas Commission for the Blind, Austin, Texas
- \* Texas Commission for the Deaf, Austin, Texas
- Texas Institute for Rehabilitation and Research  
Houston, Texas
- \* Texas Tech University, Lubbock, Texas
- \* University of Alabama Dental School, Birmingham, Alabama
- \* University of Alabama Medical School, Birmingham, Alabama
- University of Arizona Medical School, Tucson, Arizona

- \* University of California at San Diego, La Jolla,  
California
- \* University of Florida, Gainesville, Florida  
University of Florida Medical School, Gainesville,  
Florida
- University of Houston, Houston, Texas
- \* University of Iowa Medical School, Iowa City, Iowa
- \* University of Kentucky Medical School, Lexington,  
Kentucky
- \* University of Southern California Medical School,  
Los Angeles, California
- \* University of Texas Medical Branch, Galveston, Texas  
University of Texas Medical School at San Antonio,  
San Antonio, Texas
- \* University of Utah, Salt Lake City, Utah
- \* University of Wisconsin Medical College, Milwaukee,  
Wisconsin  
Veterans Administration Hospital, Albuquerque, New  
Mexico  
Veterans Administration Hospital, Bay Pines, Florida
- \* Veterans Administration Hospital, Birmingham, Alabama  
Veterans Administration Hospital, Gainesville, Florida
- \* Veterans Administration Hospital, Little Rock, Arkansas  
Veterans Administration Hospital, Long Beach ,  
California  
Veterans Administration Hospital, Memphis, Tennessee
- \* Veterans Administration Hospital, Oklahoma City,  
Oklahoma  
Veterans Administration Hospital, Salt Lake City, Utah  
Veterans Administration Hospital, Sepulveda, California  
Veterans Administration Hospital, Temple, Texas

Vocational Rehabilitation, State of New Mexico,  
Las Cruces, New Mexico

Wilford Hall Hospital, Lackland Air Force Base,  
San Antonio, Texas

Interaction with 17 new institutions was begun during this reporting period. In addition, the team identified 51 new problems.. 20 potential technology applications stand identified at contract termination, and 13 hardware technology applications were accomplished. On September 10, 1973, the team had 49 active problems under investigation.

\*Indicates the 29 medical institutions participating at contract termination.

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## 1.0 PROGRAM BACKGROUND AND METHODOLOGY

### 1.1 Applications Team Introduction

Since its creation by the Space Act of 1958, the National Aeronautics and Space Administration has been a major contributor in the advancement of technology. This technology, which has advanced the state-of-the-art of a variety of disciplines, has made possible the accomplishment of feats such as manned exploration of the moon and earth orbiting medical laboratories, which a few decades ago were considered as science fiction and impossible. Increasingly, the same technology which made these feats possible is being focused down to earth on major medical problems facing man.

Research and development programs associated with the NASA space program have created a tremendous amount of technology in virtually every scientific field. This stockpile of technology, which consists of over 800,000 documents, increases each year by approximately 75,000 entries. Much of the new technology developed is directly applicable to non-aerospace uses and diffuses into the public community through the non-aerospace divisions of aerospace contractors. Other new technology does not spread into the public community as easily. For this reason, in 1966, the NASA Technology Utilization Office, Washington, D.C., initiated an active program to assure the widest dissemination of technology resulting from the aerospace research and development programs.

Under this program, Applications Teams were established under contract to the NASA Technology Utilization Office to interface between the aerospace technology availabilities and specific public problems. There are Applications Teams established throughout the nation concentrating in such fields as air pollution control, water pollution control, transportation, mine safety, and law enforcement. There are three Applications Teams concentrating on the biomedical field. The Biomedical Applications Teams (BATEams) are comprised of small interdisciplinary groups of individuals with backgrounds in both the physical and life sciences, and are located at selected independent research centers. Each team is familiar with active areas of aerospace research, the NASA computerized collection of aerospace technology documentation, and methods of data retrieval from the information bank. The BATEams are, in effect, a human connection between the NASA data bank and the biomedical researchers and practitioners at work in medical schools, hospitals,

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clinics, and rehabilitation centers. The three BATeams are located at:

RESEARCH TRIANGLE INSTITUTE  
P. O. Box 12194  
Research Triangle Park, North Carolina 27709

SOUTHWEST RESEARCH INSTITUTE  
8500 Culebra Road  
San Antonio, Texas 78284

STANFORD UNIVERSITY SCHOOL OF MEDICINE  
Cardiology Division  
701 Welch Road, Suite 3303  
Palo Alto, California 84304

## 1.2 Biomedical Applications Team Program

The NASA BATEam program seeks to achieve the following goals:

- (1) The identification of major medical problems which lend themselves to solution by relevant aerospace technology;
- (2) The identification of relevant aerospace technology which can solve those identified problems;
- (3) The application of that technology to demonstrate the feasibility as a real solution to the identified problems;
- (4) The motivation of the industrial community to manufacture and market the identified solution to maximize the utilization of aerospace solutions in the biomedical community.

In identifying and defining these major technological problems, the BATEams actively pursue direct contact with medical researchers and practitioners in medical schools, hospitals, clinics, and rehabilitation centers. The identification and definition of the medical problems are then followed by an information search for aerospace technology that can be developed into a solution effort.

The information search for relevant technology is usually performed through three approaches:

- (1) Manual and computer searches of the NASA data bank;
- (2) Direct contacts with the research staff at NASA field centers through the individual Technology Utilization Officers, or
- (3) Circulation of biomedical problem abstracts through individual Technology Utilization Officers to the total staffs of the NASA centers.

Identified technology which may potentially solve the problem is forwarded to the "problem originator" or "investigator" through the BATEam for his evaluation of its potential applicability. At this time, if the technology is indeed applicable to the problem, ideally the problem originator implements the solution into a functional piece of hardware or technique to demonstrate the feasibility of the aerospace solution.



In an increasing number of technology applications, the problem originator is incapable of implementing the solution. The BATEams have developed the Applications Engineering Program to facilitate the implementation of solutions identified under the program. This assistance may take place at either the BATEams' facilities or at adaptive engineering facilities at NASA field centers.

The successful application of aerospace technology to a major medical problem is called a "technology application." This application includes not only the implementation of a potential solution of a major medical problem, but also the extensive evaluation of the potential solution through the loan of the NASA developed hardware to the problem originator for demonstration of the technology as a real solution.

A specialized methodology has been developed by the BATEams since they were first initiated to facilitate the application of aerospace technology. This methodology is described in the following section.

### 1.3 Biomedical Applications Team Methodology

The methodology used by the BATeams consists of five major steps: (1) problem acquisition, screening and definition; (2) identification of relevant aerospace technology; (3) evaluation of the relevant technology; (4) utilization of the technology; and (5) documentation. This methodology is outlined in Figure 1.

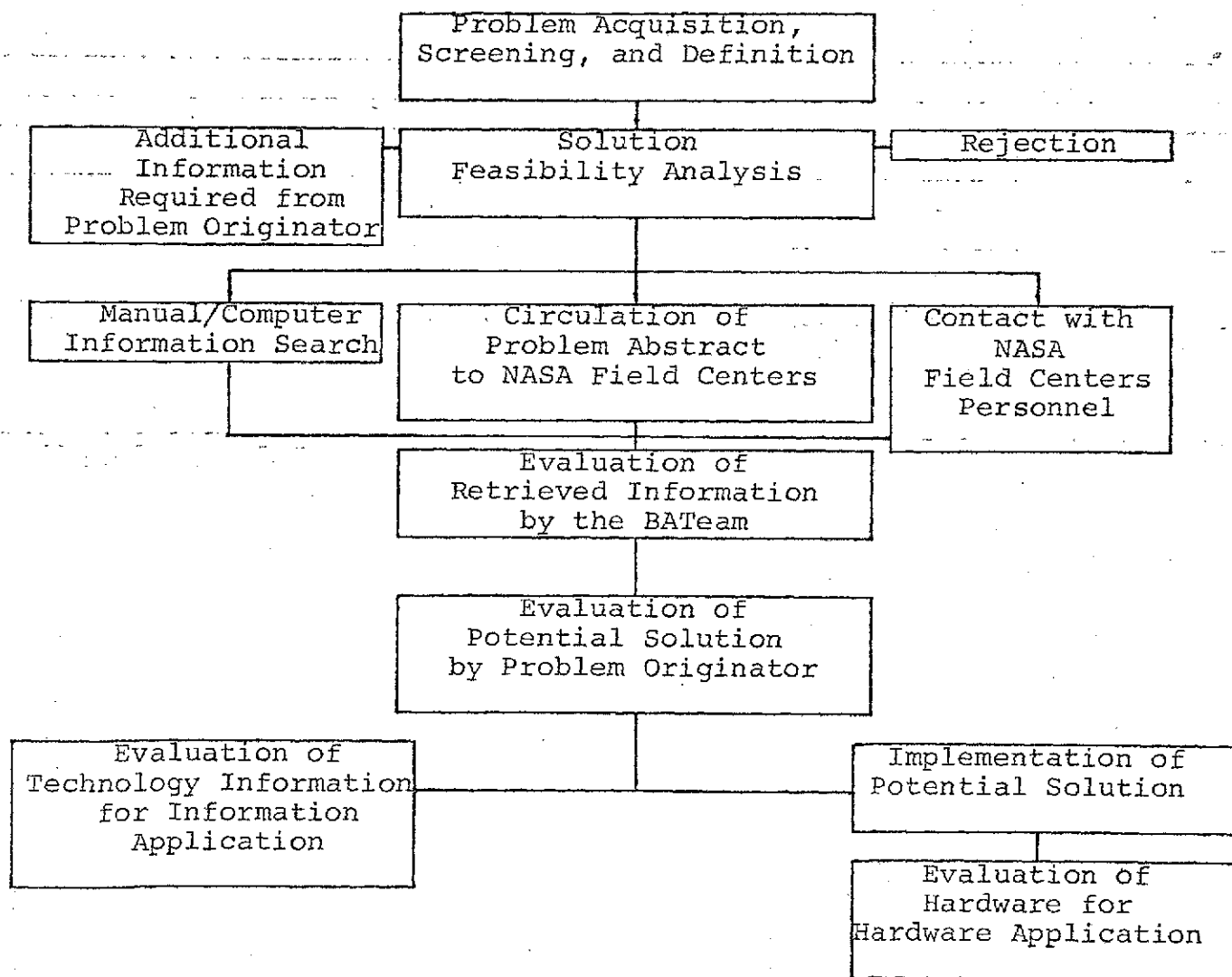


Fig. 1 Biomedical Applications Team Methodology

### 1.3.1 Problem Acquisition, Screening, and Definition

Problem acquisition is one of the most important activities of the BATEam. These problems may come to the BATEam unsolicited; in which case the problem originator has been prompted to contact the BATEam by the NASA Technology Utilization Offices, articles in professional journals describing BATEam activities, a previous problem originator, or the problem originator's own previous participation in the program.

On other occasions, the BATEam actively solicits problems, with the BATEam manager contacting institutions which might have a need for NASA Technology. Specific institutions are brought to the attention of the team manager by the NASA Technology Utilization Office; by journals describing research activities or funding; by the institution's prominence in a field of current or planned BATEam activity; or by previous experience with a user institution.

Problem definition is obtained through the joint efforts of the problem originator and a selected BATEam member who is familiar with the problem background. The objective of this step is to define precisely and concisely the problem and the required technology which would solve the problem. In many cases, after proper definition of the problem, it is found that the problem should be rejected for any number of reasons, including existence of commercially available hardware or information which can satisfy the problem requirements, or excessive problem complexity beyond the state-of-the-art of aerospace technology.

Problem screening takes place at the initial contacts with the problem originator at which time problems which are obviously unsolvable even with NASA technology are eliminated, and at periodic BATEam meetings where a new problem may require screening by a group of interdisciplinary scientists and engineers before formal rejection. Problems that do not appear to be readily solvable or require additional definition by the problem originator are rejected or returned to the problem originator.

The final product of problem acquisition, definition, and screening efforts is a problem statement. This statement, which is used throughout the processing of the problem, contains information about the problem originator, complete definition of the problem, and what is required of NASA technology in order to solve the problem.

### 1.3.2 Identification of Relevant Aerospace Technology

Relevant aerospace technology which may offer a solution to the problem is identified through three methods. The first of these is a manual and computer search of the NASA data bank. These searches are made at one of NASA's six Regional Dissemination Centers (RDC) and at NASA field center facilities. In addition, searches are made utilizing the NASA Scientific and Technical Information Facility in College Park, Maryland. The information available to the NASA data bank consists of over 800,000 documents, articles, and translations that have been abstracted in the Scientific and Technical Aerospace Reports (STAR) and the International Aerospace Abstracts (IAA). BATEam members also perform manual searches of NASA Tech Briefs, Special Publications, and Technological Surveys.

If additional information is required, or no relevant technology is identified in the manual and computer searches, the team may contact scientists and engineers at any of the ten NASA field centers directly without the preparation and dissemination of a biomedical problem abstract. This is done when a BATEam member has knowledge of a few individuals at the centers who are likely to keep abreast of the state-of-the-art in the field required by the problem.

If no relevant aerospace technology is identified by the first two methods, the BATEam prepares a biomedical problem abstract for dissemination to the scientists and engineers at all of the NASA field centers. These abstracts are circulated to selected NASA researchers by the Technology Utilization Officers at the field centers, whose job it is to keep abreast of the research and development efforts at the centers.

### 1.3.3 Evaluation of Relevant Aerospace Technology

All potentially applicable technology identified in the above searches is evaluated by the BATEam to determine whether a potential solution to the problem has been found. Those pieces of technology which the BATEam feels present a potential solution to the problem are forwarded to the problem originator along with a print-out of the computer search of the NASA data bank performed at the RDC or NASA STIF.

The problem originator must then evaluate the potential solutions. His decision to pursue a proposed solution depends on a number of factors: his evaluation of the proposed solution's validity, the cost-effectiveness of the proposed solution, and his capability to implement the solution.

#### 1.3.4 Implementation of Hardware, Evaluation of Hardware or Information

The final step in the application of aerospace technology is the implementation and evaluation of the proposed solution in a medical environment. This critical phase must occur if the technology application is to be complete; and, if at all possible, is performed at the problem originator's facilities. In some cases, however, the problem originator does not have sufficient resources for hardware fabrication and some other facility is utilized. In most instances, the SwRI BATEam has fabrication facilities available at Southwest Research Institute. In a small number of other cases, the hardware implementation is performed at a NASA field center.

After the solution has been implemented, or in the case of information applications in which hardware implementation is not necessary, it is the responsibility of the problem originator to perform a thorough and complete evaluation of the potential solution. It is only after the problem originator performs this evaluation and documents his work that the solution can be classified as a "technology application."

### 1.3.5 Documentation

Documentation is an important part of the BATEam methodology. It is involved in all terminal steps in the methodology, and in some steps where it is necessary to document potential solutions in order to prevent the duplication of effort. Documentation allows evaluation of the SwRI BATEam methodology and program in general. At present, the SwRI BATEam reports on a bi-weekly, quarterly and annual basis. This documentation also allows interaction with the BATEam by various NASA field centers whose only contact with the BATEam is the periodic reports which contain new problem statements, progress reports on current problems, and contacts with technology sources. This report covers the SwRI BATEam efforts during the contract year August 25, 1972 to September 10, 1973.

## 2.0 TECHNOLOGY APPLICATIONS, POTENTIAL TECHNOLOGY APPLICATIONS, AND BIOMEDICAL COMMUNITY IMPACTS

### 2.1 Technology Applications

#### 2.1.1 Hardware Technology Applications

Below is a list of biomedical technology applications claimed during this reporting period. On the following pages are summaries for those applications.

Page No.	Problem Title	Date Opened/Closed
AEB-1	Method for Identifying Denominations of Paper Money	06-72/03-73
AEB-2	Measurement of Physiologic Stress Parameters	06-72/01-73
AEB-3	Light Sensitive Vocational Rehabilitation Aid	06-72/09-73
AEB-4	Apparatus for Measuring Tactile Spatial Separation	06-72/09-73
CRH-8	Weight Shift Alarm for Brain Damaged and Paraplegic Persons	03-73/07-73
GLM-44	Quickly Adjustable Crutch	09-72/06-73
GLM-46	Adjustable Cradle to Cover Burn Patients	09-72/06-73
OVA-4	Assessing Sleep Psychophysiology in	12-70/05-73
RRC-8	Ultra-Thin Electromyographic Needles	01-71/09-73
SNM-26	Monitoring of Pelvic Pressure of Women in Labor	06-72/01-73
SWR-1	Custom Fitted Composite Leg Braces	02-72/09-73
TCD-9	Portable Amplifier System for Patient with Partially Inactivated Vocal Cords	10-71/01-73
TVA-2	Portable Heart Rate Indicator for Active Patients	04-72/12-72



## TECHNOLOGY APPLICATION REPORT

Problem: AEB-1 METHOD FOR IDENTIFYING DENOMINATIONS  
OF PAPER MONEY (Paper Money Identifier)

Institution: Arkansas Enterprises for the Blind  
P. O. Box 4055, Asher Ave. Station  
Little Rock, Arkansas 72204

Investigator: Elmo Knoch  
Director of Training

Acquisition Date: June, 1972 Completion Date: February, 1973

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### PROBLEM OBJECTIVE

A small, inexpensive device capable of differentiating among the various denominations of paper money was needed to permit totally blind cashiers in small vending operations to (1) insure they were not being cheated by someone giving them a one dollar bill and claiming it was a five dollar bill, and (2) insure that they could make proper change which involved paper money.

### BACKGROUND

Vocation instructors of a rehabilitation center expressed a need for a low cost, reliable device which could aid sight deficient people in identifying the various denominations of paper currency. With such a device, the potential for these handicapped people to successfully operate vending stands and other types of businesses where money must be handled would be greatly increased.

The design criteria were therefore to (1) develop a device which would allow the blind to determine the denomination of a given bill and (2) to keep unit costs to a minimum so that the device could be effectively placed in the hands of those who need them. In keeping with the second requirement it was decided to develop the device to take advantage of increased hearing and tone pattern recognition ability developed by the blind as a result of their loss of sight. The design goal was therefore to develop a device which would present audio tone patterns to the user which he could learn to recognize to determine denominations.

## RESOLUTION

With NASA Tech Brief B69-10301, "Semiautomatic Inspection of Microfilm Records" as a basic design concept, the Paper Money Identifier (PMI) was developed. The PMI consists of a hand wand which contains a light source and a sensitive phototransistor which detects the amount of light reflected from the bill. The wand is connected through a two foot cord to an electronics package containing an oscillator, an audio amplifier and a speaker. As the wand is swept over the bill in question, the amount of light reflected to the phototransistor varies according to the picture printed on the back of the bill. The changes in reflected light cause the phototransistor to conduct at different levels which in turn make the oscillator operate at different frequencies. This changing tone is amplified and fed to the speaker.

The tone pattern thus generated by passing the hand wand over the back of the bill is different for each denomination of the paper currency.

With a limited amount of practice (2-4 hours) a blind operator can learn to identify each different pattern, and therefore tell the value of any bill presented to him. With the PMI, a blind person can more confidently work at vending stands or other operations where he is required to make correct change.

## APPLICABLE NASA TECHNOLOGY

A copy of NASA Tech Brief B69-10301 follows this summary. A Technical Support Package on the PMI has also been written and is included here.

## EVALUATION

A successful evaluation of the PMI was performed by the investigator. In a demonstration with blind students of the Rehabilitation Agency of the State of Virginia at Charleston, individuals were able to learn to identify within five to six minutes \$1, \$5, \$10 and \$20 bills with no difficulty whatsoever. The investigator felt that the PMI totally met his specified criteria for the identification of denominations of currency. It is highly desirable that for production purposes the unit should be made more compact and be kept inexpensive. Inquiries as to the availability of the PMI have been numerous. Questions regarding the availability of a manufacturing license can be directed to NASA Headquarters, Patent Counsel Office. Reports on initial manufacturer interest and modifications are included in this report in Appendix B.

# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Semiautomatic Inspection of Microfilm Records

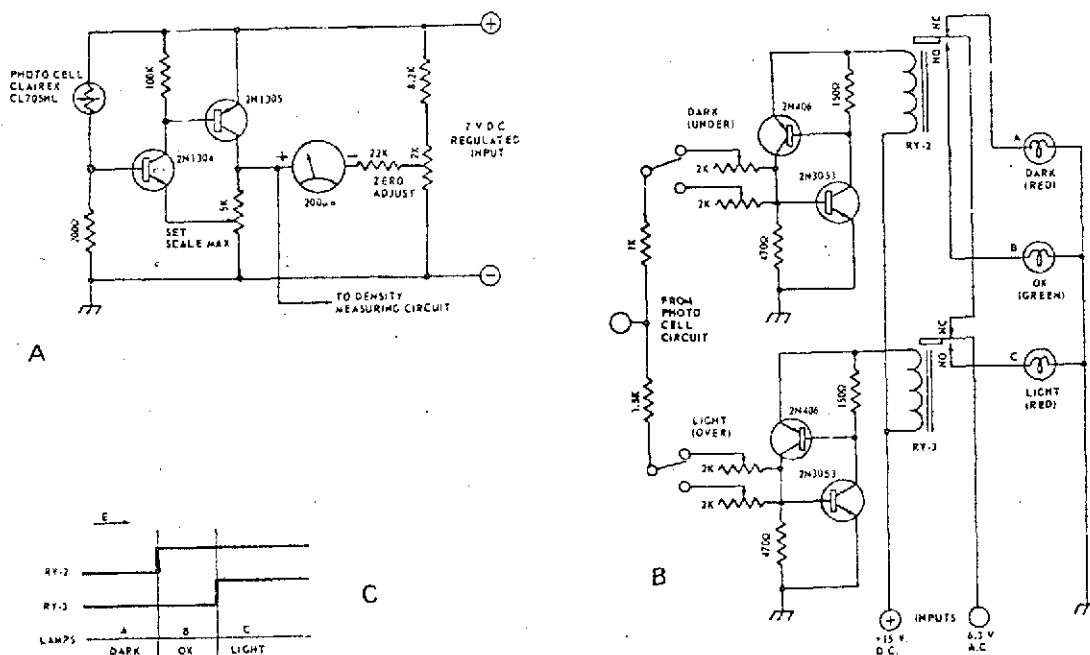


Fig. 1. MARK 1: Schematics of Photocell Circuit (A) and Density-Measuring Circuit (B), and Logic Diagram (C)

### The problem:

Microfilm in a 35mm format is the industry standard for recording engineering data and other documentation for long-term storage and retrieval. Microfilm records used by the government are controlled by Specification MIL-STD-108. This specification prescribes image size and position tolerances, resolution requirements, and density restrictions.

Heretofore, microfilm inspection has been done manually, using an individual microscope, a densitometer, a light box, and hand-cranked reels. This method is not only time-consuming but it is some-

times of questionable quality since subjective judgment of the inspection personnel is a major factor.

### The solution:

Inasmuch as deficiencies in microfilm quality are undetected by this nonuniformity of inspection apparatus it follows that these deficiencies can be alleviated by providing a semiautomatic-type inspection machine for this purpose. Accordingly, two working models were designed and constructed by the support contractor to the MSFC Management Services Office. Improvements in reliability and ease of operation

(continued overleaf)

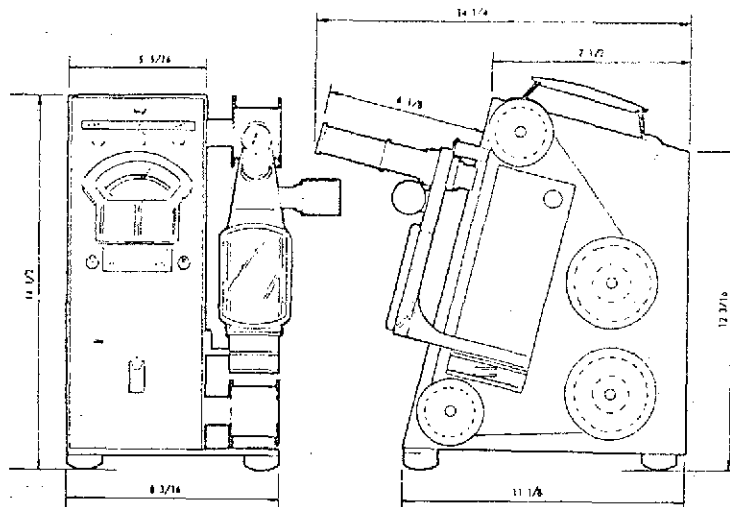


Fig. 2. Outlines of MARK II; Dimensions are in inches.

were made in the second prototype identified as MARK II.

#### How it's done:

The microfilm inspector utilizes motor-driven film reels with a means for precisely positioning the microfilm image for inspection. Film density is measured by means of a photoelectric cell and solid-state electronic circuit. Over and under tolerances are preset according to specification. As the film is inspected, go-no-go indicator lights advise the operator of the film status. In addition to the lights, a densitometer provides specific values for film density. These are recorded to back up the film-inspection report.

Resolution of the photographic image on the film is determined by a microscope which is an integral part of the machine. Image size and position are also determined by a built-in optical device.

Principal advantages of the microfilm inspector are:

1. Uniformity of inspection method.
2. Increased speed of inspection.

3. Improved quality through elimination of scratches, dust, and finger marks, etc.

#### Note:

Documentation is available from:  
 Clearinghouse for Federal Scientific  
 and Technical Information  
 Springfield, Virginia 22151  
 Price \$3.00  
 Reference: TSP69-10301

#### Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546

Source: E. L. Klein of  
 RCA Service Company  
 under contract to  
 Marshall Space Flight Center  
 (MFS-20240)

DESCRIPTION AND OPERATING INSTRUCTIONS  
for  
PAPER MONEY IDENTIFIER

NASA BIOMEDICAL APPLICATIONS TEAM

Problem AEB-1

March 1973

## PAPER MONEY IDENTIFIER

### Abstract

As a result of activity of Southwest Research Institute in support of the NASA sponsored Biomedical Applications program, a need was identified for a low cost, reliable device which would allow sight deficient people to identify the denominations of U.S. paper currency. In response to this need, the Institute has developed the Paper Money Identifier. This device makes use of an optoelectronic scanner and a voltage controlled oscillator to generate audio tone patterns which are used by the blind operator to determine the value of the various denominations. With a minimum of training (approximately 4-6 hours) the operator can learn to identify the unique tone pattern generated by each value of paper currency and thereafter identify the value of any bill handed him. With the PMI, a blind person may more confidently work at vending stands or other operations where he is required to handle and change money.

## Brief Technical Description of the Paper Money Identifier

The Paper Money Identifier (PMI) allows a sight deficient operator to identify the denomination of various pieces of paper currency by generating a varying audio tone pattern as it is passed over a given bill. The unit consists of two major sections; the hand wand and the electronics package.

The hand wand consists of an optoelectronic scanner mounted in a suitable holder. The scanner contains a light source and a sensitive phototransistor which responds to the amount of light reflected from the object under test. The holder is constructed of two pieces of threaded tubing to allow for sensitivity adjustment depending on the ambient lighting conditions of the work area. The entire wand is connected to the electronics package by a two foot cable.

The electronics package contains a voltage controlled oscillator and amplifier circuit to convert the changing conduction levels of the phototransistor into a varying audio tone. The VCO is controlled by the phototransistor through a voltage divider network and its output is fed through the amplifier to a built-in speaker. Provision is also provided for the use of an earphone if the operator prefers.

The entire unit is powered by a dual output power supply which operates on standard 120 VAC 60 Hz current. The 5 VDC output operates the light source in the wand with the remainder of the circuitry operating from the 12 VDC output.

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I Introduction

II Operating Instructions

III Technical Discussion

IV Conclusion

Appendix 1 - Parts List and P.C. Layout

## LIST OF FIGURES

Figure 1 Paper Money Identifier

Figure 2 Front Panel Layout

Figure 3 Functional Block Diagram

Figure 4 PMI Schematic



## I. Introduction

The Paper Money Identifier was developed in response to a need for a low cost, reliable device which would aid sight deficient people in identifying the various denominations of U.S. paper currency. With such a device, the potential for these handicapped people to successfully operate vending stands and other types of businesses where money must be handled would be greatly increased.

The design criteria were therefore to (1) develop a device which would allow the blind to determine the denomination of a given bill and (2) to keep unit costs to a minimum so that the device could be effectively placed in the hands of those who need them. In keeping with the second requirement it was decided to develop the device to take advantage of increased hearing and tone pattern recognition ability developed by the blind as a result of their loss of sight. The design goal was therefore to develop a device which would present audio tone patterns to the user which he could learn to recognize to determine denominations.

Concepts derived from NASA and other government sponsored research efforts were utilized in the development of the PMI. An opto-scanner was used to control the output frequency of a voltage controlled oscillator with suitable amplifier circuitry to present the tone pattern to the operator through either a speaker or earphone. Controls were kept to a minimum with volume level and wand sensitivity the only adjustments required.

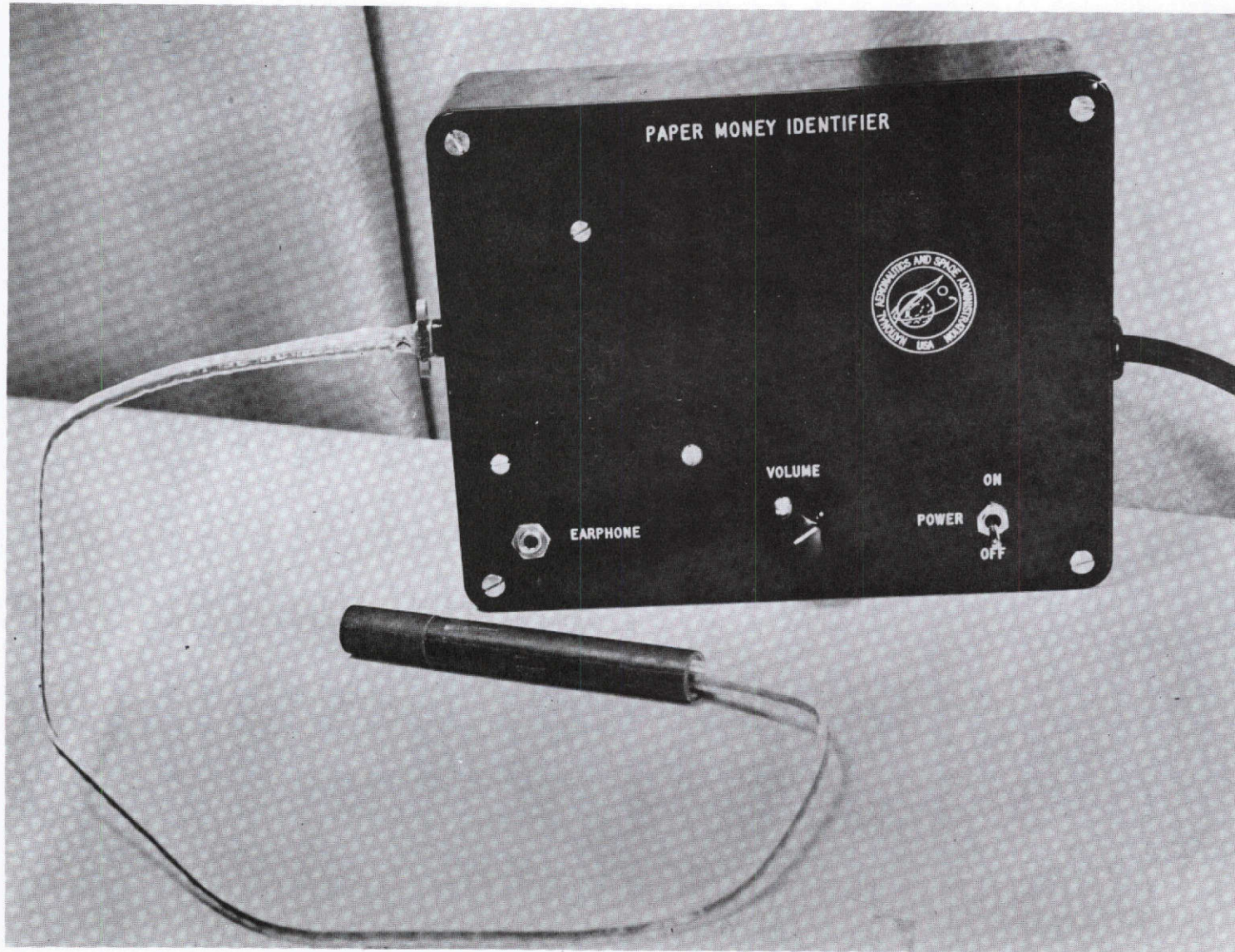


Figure 1 - Paper Money Identifier

## II. Operating Instructions

The Paper Money Identifier (PMI) consists of a hand held wand attached through a two foot cable to an electronic package which generates the audio tones used to determine the denomination of paper currency. As the wand is passed over the surface of the bill in question, a unique tone pattern is generated which indicates the value of the currency.

### Controls

The following is a list of all the connections and controls used on the PMI: (see Figures 1 and 2)

1. A.C. Power Cord-The AC power cord is permanently attached to the right side of the package. The cord can be plugged into any convenient 110 VAC, 60 Hz outlet.
2. Wand - Plug the wand cable into the 5-pin connector located on the left side of the package. This is a keyed connector and cannot be improperly inserted.
3. Power Switch - This switch is located on the face of the package in the lower right-hand corner. Up is on, down is off.
4. Volume Control - This control is located in the lower center portion of the face. Turning the knob clockwise will increase the volume of the tones generated.
5. Earphone Plug - At the option of the operator, an earphone may be used instead of the speaker built into the system. A jack for the earphone is provided in the lower left-hand corner of the face of the PMI. When the earphone plug is inserted, the speaker is disconnected and volume control will vary the sound level to the earphone.

### Operation

Once the power cord and wand connections have been made as explained in the previous section, the PMI is placed in operation by turning on the power switch. When the unit is turned on, a low frequency clicking sound may be heard. Place the tip of the wand on any convenient surface. This will cause a tone to be generated which can be used to set the volume to the desired level.

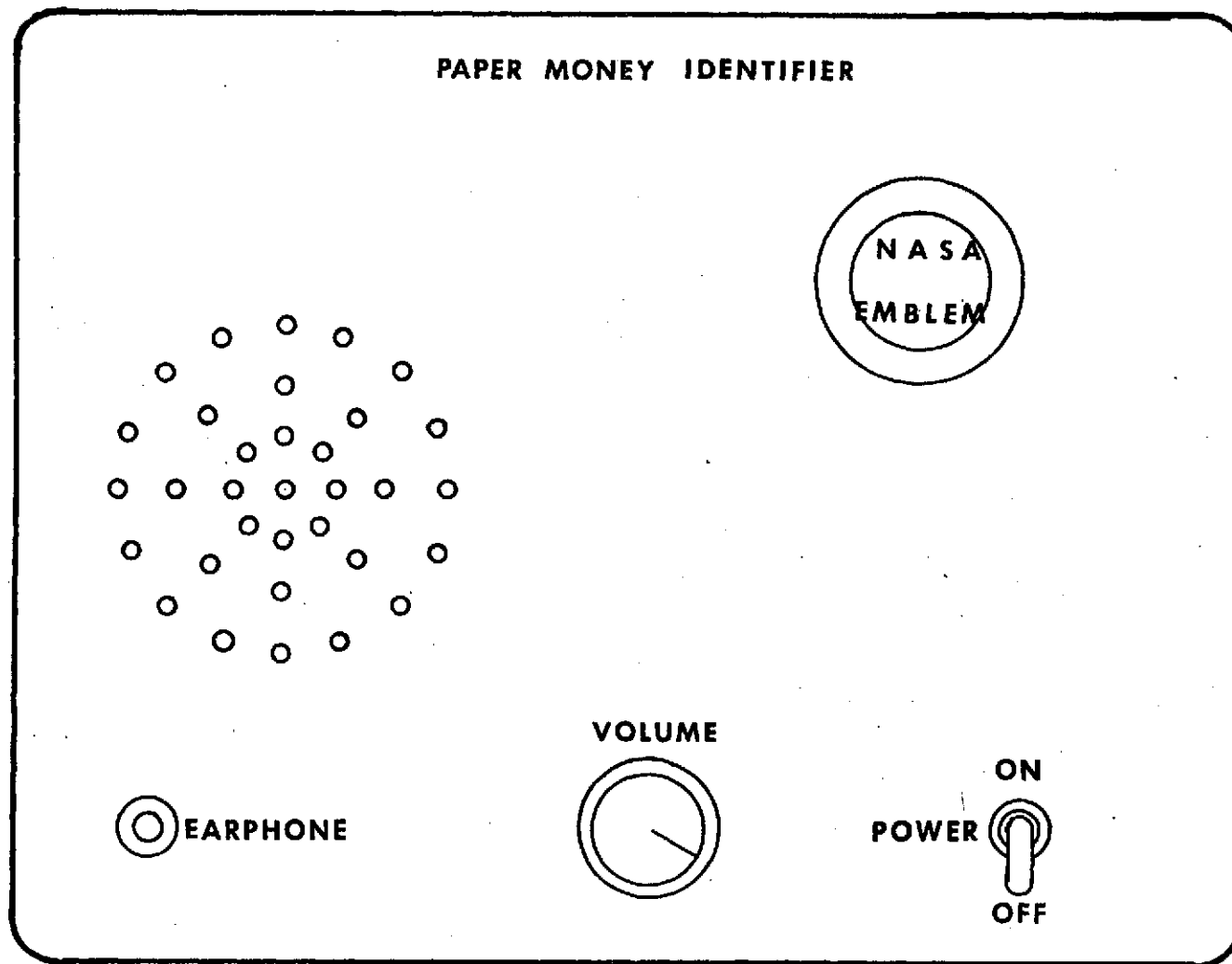


Figure 2 - Front Panel Layout



## Identification of Paper Currency

There are many areas on the different denominations of paper currency which will generate unique tone patterns for use in determining the value of a paper bill. With experimentation and practice the operator can determine which of these areas is most satisfactory for his use. The following description indicates just one of these areas and how it can be used to determine the value of various bills.

When given a bill of unknown value, place it on a smooth, flat surface in such a manner that the PMI wand can be placed down and swept along the center of the long dimension of the bill. Sweep the wand back and forth across the bill and listen to the varying tone pattern generated by the PMI.

The front or face side of all denominations will sound about the same, with high tones at the beginning and ending of the sweep and low, deep tones in the center. With a minimum of practice the face side can be readily identified. If it is determined that the bill is face up, turn the bill over.

The back, or picture side, of each denomination is unique. The Great Seal of the United States and the large printed word "one" are on the back of a one dollar bill. A picture of the Lincoln Memorial on a light background is on the back of a five. The ten has a picture of the Treasury Building on the back, and the White House surrounded by trees is shown on a twenty dollar bill. Each of these pictures will generate a unique tone pattern as the wand of the PMI is swept back and forth across the bill. With practice the operator will learn to identify each of the denominations by the tone pattern generated when the wand is scanned across the picture on the back side of the bill.

As mentioned earlier, this is not the only unique section of the various denominations. Experimentation and practice should allow the operator to identify other areas which may be useful in determining the value of a given piece of paper currency.

## Sensitivity Adjustment

The sensitivity of the PMI wand has been adjusted to give the desired tone signals under the lighting conditions it is anticipated will be used. If the actual conditions are somewhat different than anticipated, further adjustment may be necessary. Sensitivity adjustments may be made in the following manner.

The tip of the PMI wand is made of a piece of threaded tubing which is screwed onto the sensing element and held in place by the threaded handle. To adjust the sensitivity of the wand, loosen the handle and turn the tip piece to the desired position. If the tip of the wand is facing the operator, clockwise rotation will screw the tip further onto the sensor and increase sensitivity. Increasing sensitivity will increase the response of the wand to the pictures scanned and also cause a general rise in the frequency of the tone pattern generated. Counterclockwise rotation of the tip will have an opposite effect on system operation.

Once the operator is familiar with the operation of the system, he may desire to experiment with various sensitivity settings to find the one best suited for his particular use.

Caution: Once the desired sensitivity setting is located, be sure to retighten the threaded handle to hold the tip in place.

### III. Technical Discussion

Electronically, the PMI is divided into three sections: the optoelectronic scanner, the voltage controlled oscillator, and the amplifier/speaker. Each of these sections is discussed individually in the following paragraphs (Ref. Figures 3 and 4).

Scanner. The optoelectronic scanner is located in the hand wand attached to the main package by two feet of cable. The scanning device consists of a light source and phototransistor mounted in a threaded aluminum tube. To minimize the heating affect of the light, it and the phototransistor are located at opposite ends of the tube; the phototransistor being at the tip and the light at the back. A fiber optic bundle is used to transmit the light from the source to the tip of the device. This bundle has been arranged in a coaxial configuration so that the phototransistor is surrounded by the effective light source. A 5 VDC power supply located in the main package supplies power for the light. The phototransistor is connected through the cable to the voltage controlled oscillator.

Voltage Controlled Oscillator. The VCO consists of a NE566 function generator and its associated components. The phototransistor is part of the voltage divider network  $R_1$ ,  $R_2$  connected to pin 5 of the VCO. The resistor values were chosen to allow a nominal frequency change of 1000 Hz between the darkest and lightest areas of a bill. This will vary slightly if the scanner sensitivity is changed. (See operating instructions). The components  $R_3$  and  $C_2$  determine the nominal operating frequency of the NE566 and were chosen to produce an output of approximately 1300 Hz with the phototransistor saturated. Dark area tones therefore range down to near 300 Hz with optimum sensitivity settings. Both square and triangular wave outputs are available; the triangular output which has a peak-to-peak amplitude of slightly over 2 volts is used to drive the amplifier/speaker.

Amplifier/Speaker. Due to the relatively high output voltage of the VCO, only a single power amplifier stage is required. The output of this stage is transformer coupled to the built-in speaker and provides sufficient volume for all but the noisiest of environments. An optional earphone output is provided for use under these conditions.

Both the VCO and the amplifier/speaker stages are powered from the 12 VDC output of the power supply. The input to the dual power supply is fused to prevent serious damage in case of the failure of either supply.

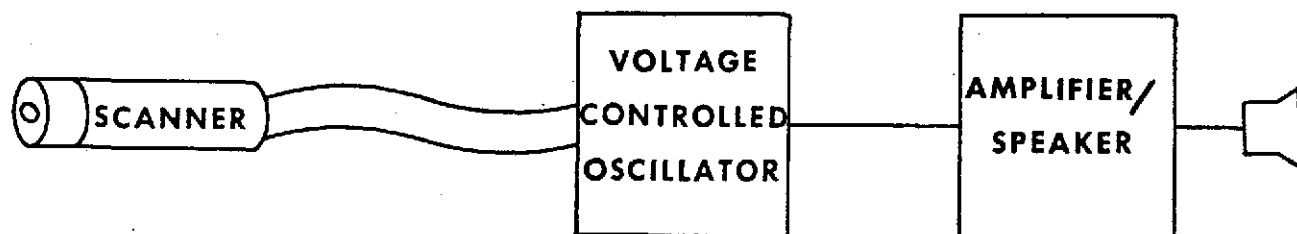


FIGURE 3 — BLOCK DIAGRAM

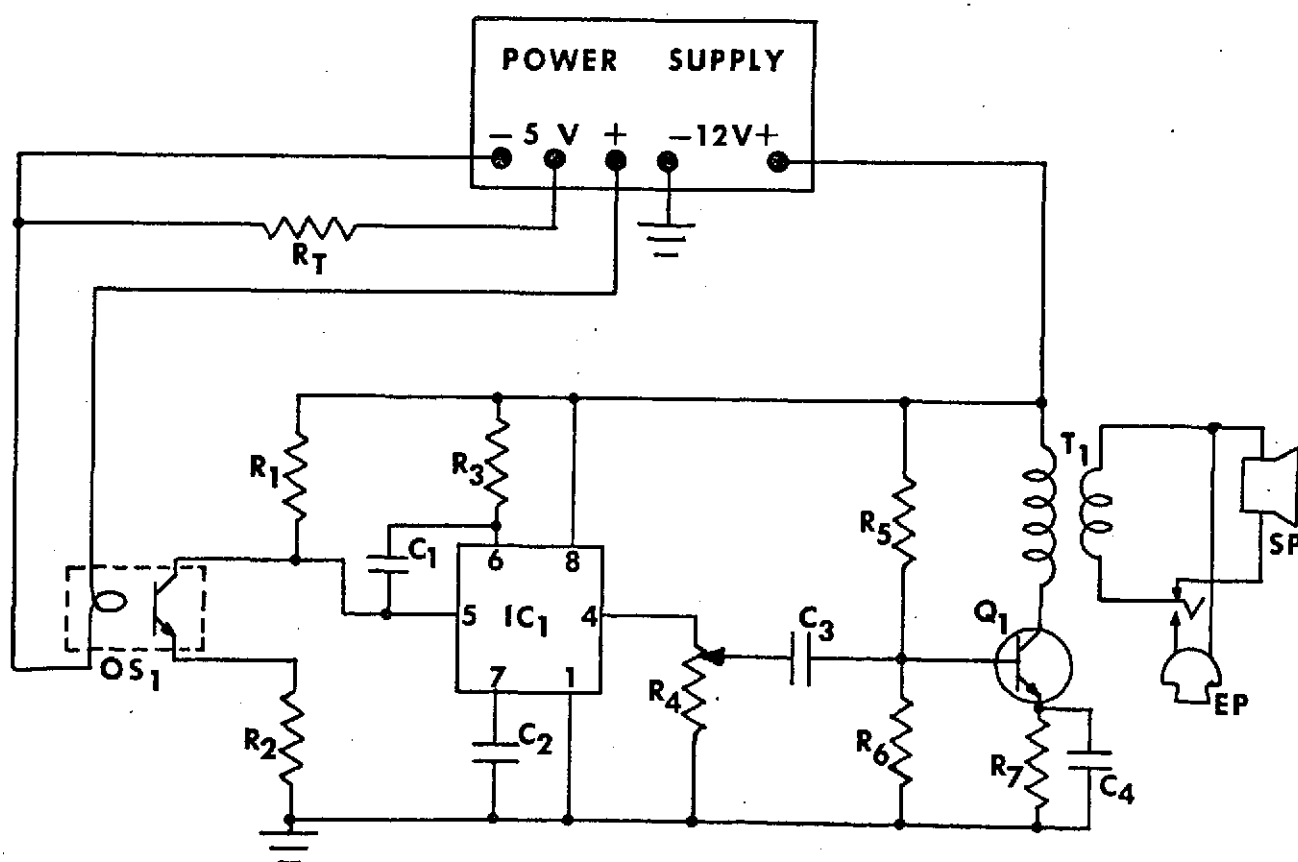


FIGURE 4 — PMI SCHEMATIC



#### IV. Conclusion

The Paper Money Identifier is an inexpensive, reliable device which allows the sight deficient person to determine the value of the various denominations of paper currency. Using the PMI, blind operators may more confidently function as vending stand operators or employees in jobs where the handling of money is required.

While the PMI was designed for a specific purpose there may well be other uses found which will aid the blind in dealing with their environment.

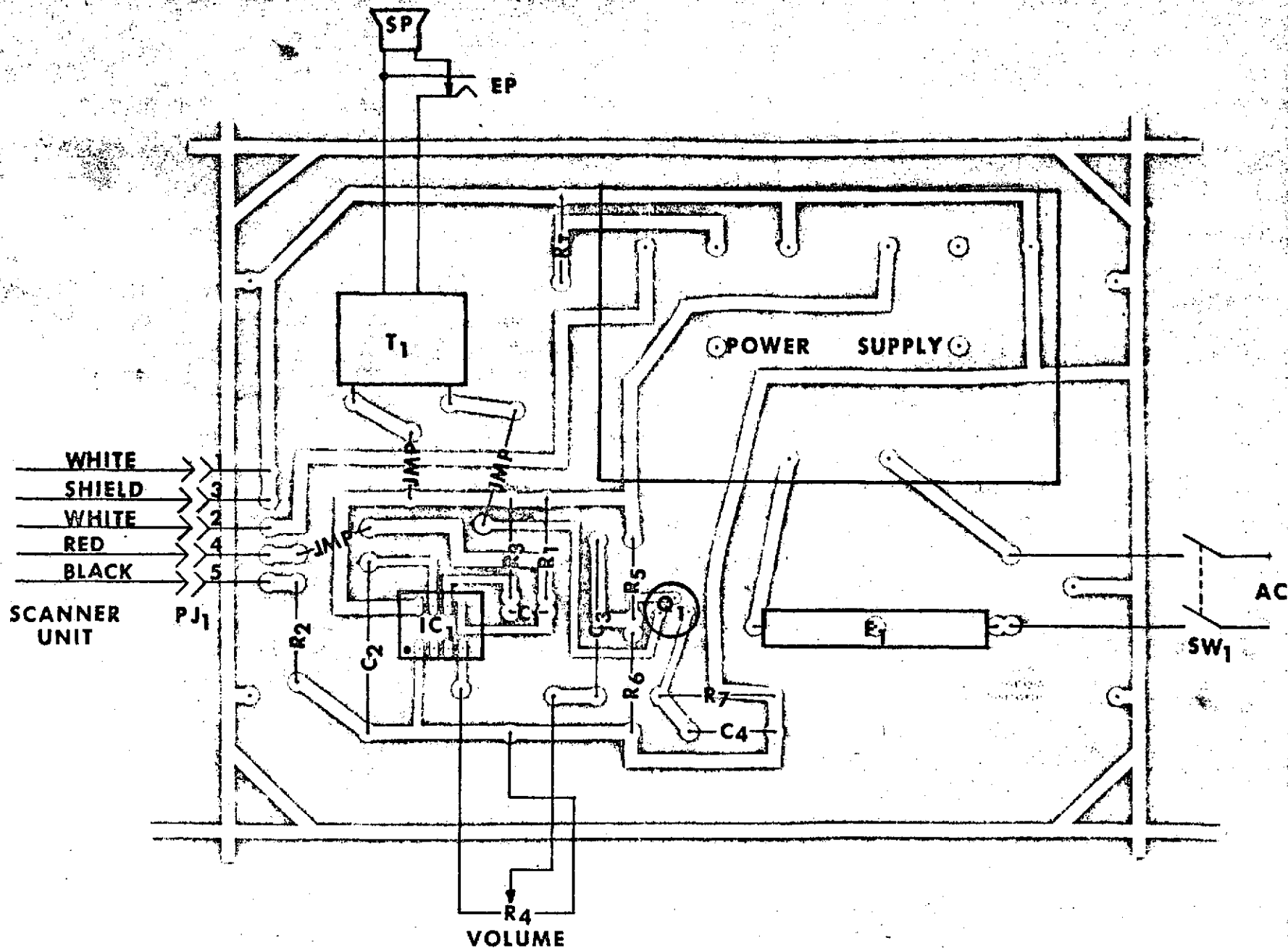
## APPENDIX A

Parts List and P.C. Layout

## Paper Money Identifier

## Parts List

- R<sub>1</sub> 2.7K, 5%, 1/4 w, composition  
 R<sub>2</sub> 15K, 5%, 1/4 w, composition  
 R<sub>3</sub> 10K, 5%, 1/4 w, composition  
 R<sub>4</sub> 10K, 10%, miniature potentiometer, 1/2" dia.  
 R<sub>5</sub> 6.2K, 5%, 1/4 w, composition  
 R<sub>6</sub> 1K, 5%, 1/4 w, composition  
 R<sub>7</sub> 51 ohms, 5%, 1/4 w, composition  
 R<sub>T</sub> 510 K, 5%, 1/4 w, composition — may vary with power supply.  
 Select value to give 4.9 volts into 50 ohm load.
- C<sub>1</sub> 0.01 uf, ceramic disc.  
 C<sub>2</sub> 0.027 uf, Tex-cap type 315  
 C<sub>3</sub> 1.0 uf, Tex-cap type 315  
 C<sub>4</sub> 0.5 uf, Tex-cap type 315
- Q<sub>1</sub> 2N222, silicon NPN  
 1C<sub>1</sub> NE566V, function generator, Signetics
- T<sub>1</sub> TA-26 Transistor output transformer,  
 primary 1250 ohms, secondary 4/12 ohms, Stancor
- Sp Speaker, Miniature 8-ohm, 2-1/4" dia.,  
 Cal Electro Type S2-0203.
- Ep Jack TR-2A micro-jax, Switchcraft.
- OS<sub>1</sub> Scan-coax fiber optic skanner, Type  
 TS-322-3. Scan-A-Matic Corp. P.O. Box S, Elbridge, N.Y. 13060
- P.S. Dual output regulated power supply,  
 Model 5E25D-12E10D, Acopian Corp.
- PJ<sub>1</sub> Series 223 "Tiny Tim" connectors. Plug Type 223-1105,  
 Recept. Type 223-1205. Pins: male type 220-PO2, female type  
 220-S02. Amphenol
- Fuse Holder Single pole fuse block, Type 4405, BUSS
- F<sub>1</sub> Fuse, .1 amp, 1-1/4 x 1/4.
- Case Base: Type 260 Instrument case, 6-13/16 x 5-9/32 x 2-5/16.  
 Cover: Type 261 Instrument cover.  
 Harry Davies Molding Co., 4920 W. Bloomingdale Ave.  
 Chicago, Ill., 60639



P.C. LAYOUT

## TECHNOLOGY APPLICATION REPORT

Problem: AEB-2 MEASUREMENT OF PHYSIOLOGIC STRESS  
PARAMETERS

Institution: Arkansas Enterprises for the Blind  
P. O. Box 4055, Asher Ave. Station  
Little Rock, Arkansas 72204

Investigator: Elmo Knoch  
Director of Training

Acquisition Date: June, 1972 Completion Date: February, 1973

-----

### PROBLEM OBJECTIVE

A wireless method of monitoring ECG was needed to enable vocational rehabilitation instructors to determine the amount of stress generated in blind trainees by new situations and tasks.

### BACKGROUND

Monitoring heart rate on convalescing heart patients has been routine for some time. However, most therapists must manually record pulse rate before stress period and after at prescribed intervals. There has been and is now a definite need for a small, inexpensive beat-to-beat cardi tachometer that will allow a therapist to obtain an objective measure of the amount of stress on an individual. This is important both in terms of (1) prediction of success once the trainee has been placed vocationally, and (2) in adjusting the training program so as to produce maximum results.

### RESOLUTION

The investigator and BATEam personnel determined that the following design goals had to be met by the proposed cardi tachometer:

1. Heart rate must be measured accurately on both a meter and auxillary output.
2. Instrument must be portable and durable.
3. Instrument must have a calibration range of 50-140 beats per minute (BPM).

4. Instrument must be versatile in type of inputs, electrodes, recorder, telemetry, etc.

Final design criteria included NASA Technology from Johnson Space Center on cardiometers and special circuitry, Ames Research Center on biotelemetry, and Southwest Research Institute state-of-the-art engineering techniques in combining all technology into an instrument providing reliable heart rate information.

This instrument has the ability to monitor ECG biopotentials either directly via electrodes, or from auxillary devices such as tape recorders, telemetry systems, and chart recorders. The entire system fits into a small case with a shoulder strap for ambulatory use. Further miniaturization is possible, but for cost-effective design, the prototypes were not reduced to a hand-held unit.

The instrument includes three subsystems depending upon design requirements:

1. Cardiometer
2. Transmitter
3. Demodulator

For the telemetry requirement, a standard broadcast FM receiver is the only additional item required.

The cardiometer receives ECG biopotential signals, recognizes the R wave, and squares it. A FET and reed relay comprise a sample and hold circuit which drives the meter and the output with a staircase signal.

#### APPLICABLE NASA TECHNOLOGY

Copies of NASA Tech Briefs B64-10171, B65-10010, and B65-10143 follow this summary. A Technical Support Package on the cardiometer has been written and is included here.

#### EVALUATION

On July 9, 1973, the investigator reported that a proper evaluation of the cardiometer was not possible at that time. He is presently repairing the damage to the device which occurred during shipment. The investigator has stated in his preliminary evaluation that the device will be extremely useful and that the hardware will meet the necessary requirements.

The investigator utilizes a Hewlett Packard oscilloscope, a Heathkit interface, a PDP8 mini-computer and associated terminals including braille output, radio receivers, and special antennas to increase range with the cardiometer provided.

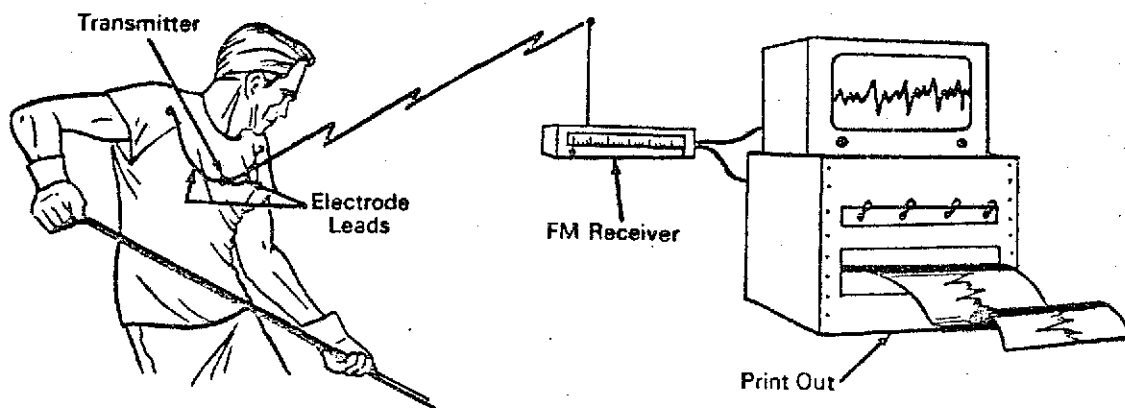
In addition to his repair efforts, the investigator is attempting to increase the range of the device. The BATEam designed the cardiometer to have an effective range of 200 feet. Because of expanded application needs they wish to expand the range to 30 miles and they are currently enlisting the cooperation of the U.S. Air Force in adapting circuitry design from long range military walkie-talkies.

# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Subminiature Biotelemetry Unit Permits Remote Physiological Investigations



**The problem:** The measurement of biopotential response in humans or animals to controlled environmental stimuli has traditionally been impaired by encumbering electrical leads or bulky amplifying and transmitting equipment.

**The solution:** A subminiature, high-performance, biopotential telemetry transmitter operating in the standard 88- to 108-megacycle FM band.

**How it's done:** The transmitter was designed using standard, inexpensive, commercially available components and assembly techniques which permit easy and repeatable assembly with no sacrifice of performance or reliability. The transmitter is 0.74 inch in diameter by 0.20-inch thick and weighs two grams. A mercury cell provides power for operation in two modes, selected by the interchange of three components in the basic circuit. In one mode the transmitter has a two-day operating life with a 100-foot range; in the other, the transmitter has a 48-day operating life with a 10-foot range. Conventional biomedical electrodes are used to connect the transmitter to the subject.

### Notes:

1. In tests, humans have worn the unit for four or five days without discomfort and have generated useful data while engaged in normal activities.
2. Further information concerning this innovation is described in NASA-TM-X-54068, "A Miniature Biopotential Telemetry System" by Gordon J. Deboo and Thomas B. Fryer, May 1964.
3. A related innovation is described in NASA Tech Brief 64-10025, May 1964.
4. Inquiries may also be directed to:

Technology Utilization Officer  
Ames Research Center  
Moffett Field, California, 94035  
Reference: B64-10171

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Ames Research Center (ARC-39)

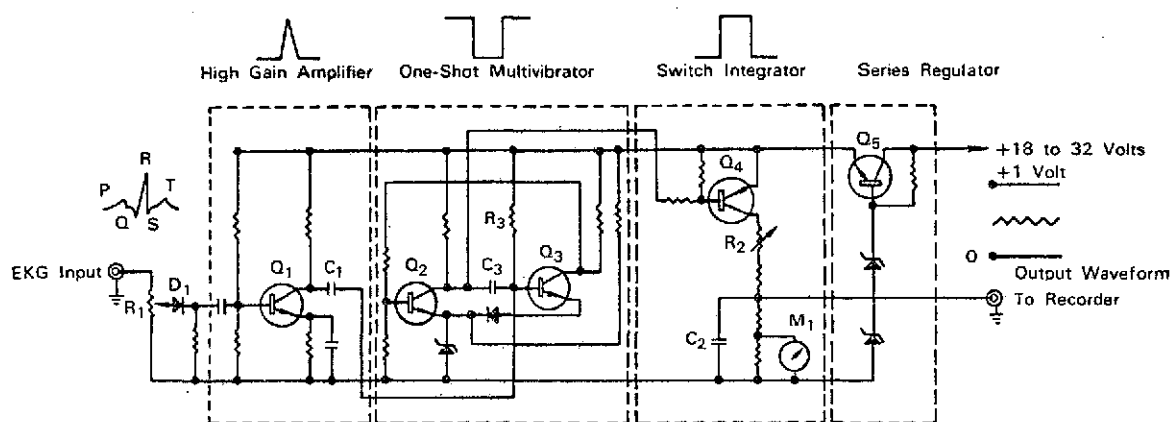


# NASA TECH BRIEF



NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Inexpensive, Stable Circuit Measures Heart Rate



**The problem:** Although circuits for measuring heart rate have been available for some time, they have either been more complex than basically necessary in order to accommodate a wide range of applications, or have been available only as part of an electrocardiograph (EKG) system. There is a need for a simple, inexpensive circuit that will provide a reliable indication of average heart rate.

**The solution:** An inexpensive, stable, transistorized circuit that provides an accurate analog indication of average heart rate in response to a preamplified EKG signal applied to its input. The device provides a meter indication of heart rate in addition to a proportional output voltage which may be fed to a high-input impedance recorder.

**How it's done:** The circuit uses the R-wave (positive spike) of an EKG signal to trigger a pulse generator. The metering circuit is basically an integrator which uses the constant-width, constant-amplitude pulses from the generator to produce a voltage

proportional to the frequency of the pulses. The EKG input signal is applied across the trigger level control  $R_1$  which is set so that  $D_1$  passes only the large positive spikes (R-waves) of the signal. This spike is amplified by a high-gain, common emitter amplifier ( $Q_1$  and associated circuitry) and then coupled to a one-shot multivibrator through  $C_1$ . The multivibrator ( $Q_2$  and  $Q_3$ ) produces a constant-duration, constant-amplitude, square-wave output for every input pulse from the amplifier. With no pulse present,  $Q_3$  is conducting and  $Q_2$  is cut off. Arrival of the negative pulse at the base of  $Q_3$  decreases its collector current, producing a positive pulse at the base of  $Q_2$ . This causes an increase in the collector current of  $Q_2$  and a corresponding negative shift of its collector voltage. This negative pulse is fed back to the base of  $Q_3$  causing a rapid switch in the conditions of  $Q_2$  and  $Q_3$  ( $Q_2$  turns on,  $Q_3$  turns off). The pulse duration is determined by the  $C_3R_3$  time constant after which  $Q_2$  and  $Q_3$  revert to their original states.

(continued overleaf)

The square-wave pulses from the multivibrator are coupled to the base of  $Q_4$  which controls the average rate of current flow to the resistor-capacitor integrating network. An increase in the frequency of the square-wave signal causes an increase in  $Q_4$ 's collector current and a corresponding increase in the voltage across  $C_2$ . Output for a recorder with a high-input impedance (10,000-ohms minimum at 1 volt) is available directly across  $C_2$ . Resistor  $R_2$  is adjusted to provide full-scale deflection of  $M_1$  with an average heart rate of 200 beats per minute. An internal series voltage regulator is provided in the circuit for portable operation with batteries. If a constant voltage source is available, the regulator circuit ( $Q_5$  and associated circuitry) may be omitted.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer  
Manned Spacecraft Center  
P.O. Box 1537  
Houston, Texas, 77001  
Reference: B65-10010

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

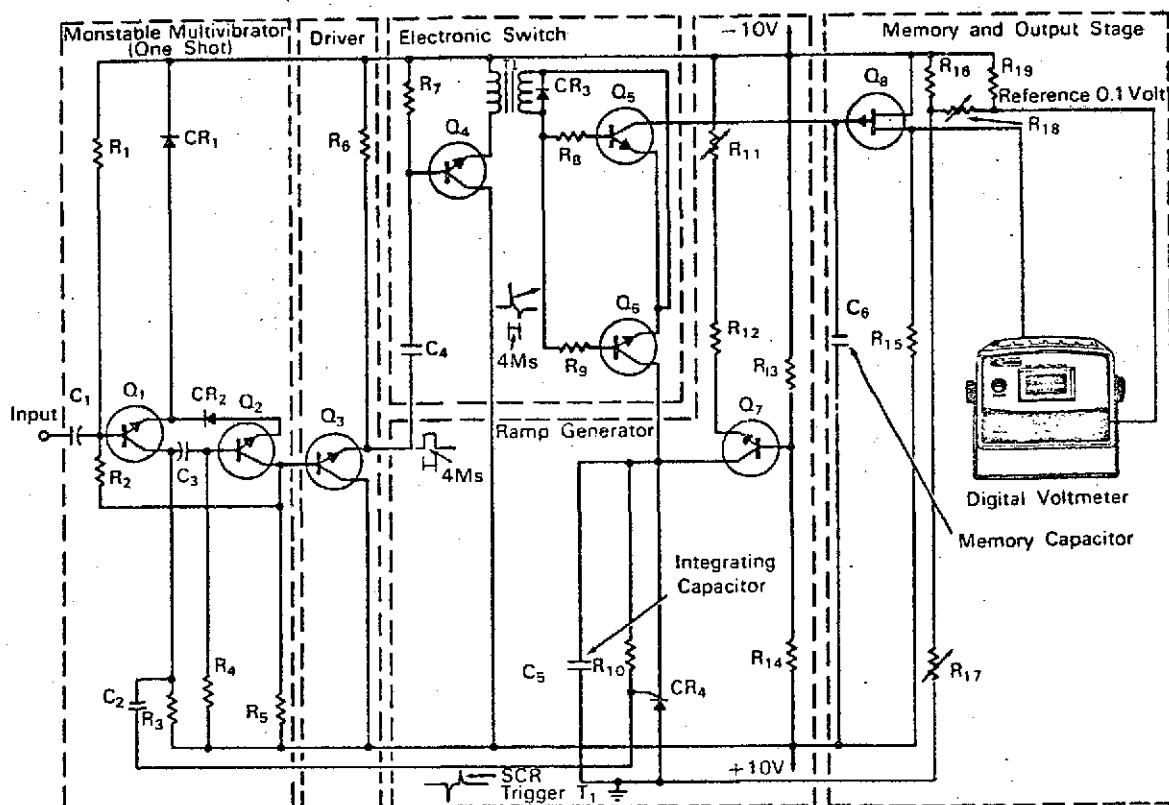
Source: Howard A. Vick  
(MSC-95)

# NASA TECH BRIEF



NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Digital-Output Cardiometer Measures Rapid Changes in Heartbeat Rate



**The problem:** Analog cardiometers are inherently nonlinear and do not respond with sufficient speed to indicate rapid changes in heartbeat rate. Those digital cardiometers that are capable of measuring heartbeat rate on a beat-by-beat basis are generally complex and costly.

**The solution:** A cardiometer circuit that produces an output voltage proportional to the heartbeat

rate on a beat-by-beat basis. Direct readings in beats per minute are obtained on a linear scale of a digital voltmeter. This circuit is designed to be used with an auxiliary circuit (described in NASA Tech Brief B65-10142, May 1965) that converts a subject's electrocardiogram into square-wave pulses at a frequency proportional to the heartbeat rate.

(continued overleaf)

TECHNICAL SUPPORT PACKAGE FOR  
PORTABLE BEAT TO BEAT CARDIOTACHOMETER

NASA BIOMEDICAL APPLICATIONS TEAM  
SOUTHWEST RESEARCH INSTITUTE

Problems TVA-2 and AEB-2

January 16, 1973

**How it's done:** The square-wave pulses from the auxiliary circuit are applied as the input to the cardiometer. These pulses trigger the monostable multivibrator ( $Q_1$ - $Q_2$ ) which converts them into short-duration (4-millisecond) square-wave pulses. The narrow pulses pass through the driver stage,  $Q_3$ , and are differentiated in the  $Q_4$  emitter and  $T_1$  transformer circuit. The positive-going portion of the differentiated square wave appearing on the secondary of  $T_1$  passes to the base elements of the normally cut off switching transistors  $Q_5$  and  $Q_6$ . On receipt of a positive pulse, these transistors are turned on to transfer the voltage developed on integrating capacitor  $C_5$  to the memory capacitor  $C_6$ . A few milliseconds later, the silicon controlled rectifier (SCR),  $CR_4$ , is triggered and shorts out the charge on  $C_5$ . The SCR then returns to the quiescent state and  $C_5$  becomes ready to start another cycle when the next positive pulse appears.

Capacitor  $C_5$  is sampled and then shorted out each time a 4-millisecond pulse is generated. The time between pulses is relatively long (0.3 to 3 seconds). During this interval,  $C_5$  will continue to charge at a linear rate through  $Q_7$  toward -10 volts, until the next heart beat (4-millisecond pulse) activates the switching transistors to transfer the charge from  $C_5$  to  $C_6$ . Transistor  $Q_7$  provides the constant-current source necessary for a linear charge rate, so that the amplitude of the ramp voltage on  $C_5$  is a function of the time between heart beats.

The charge on  $C_6$  biases the field effect transistor,  $Q_8$ , to control the current through  $R_{15}$ . Since a field

effect transistor is a high-impedance device, the charge on  $C_6$  will not leak off between pulses. The voltage across  $R_{15}$  is therefore a function of this charge. This output voltage is applied to a commercial digital voltmeter in a unique manner. Normally the voltage would be applied to the voltmeter's input terminals. Instead, the output voltage is applied to the voltage reference circuit inside the meter case and a 0.1-volt reference is applied to the input terminals. The digital voltmeter is thus connected as an electronic divider or ratiometer to provide readings of the heartbeat rate directly in beats per minute.

#### Notes:

1. An analog cardiometer is described in NASA Tech Brief B65-10010, January 1965. Inquiries may also be directed to:

Technology Utilization Officer  
Manned Spacecraft Center  
P.O. Box 1537  
Houston, Texas, 77001  
Reference: B65-10143

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Howard Vick  
(MSC-133)

## PORTABLE BEAT-TO-BEAT CARDIOTACHOMETER

### ABSTRACT

Monitoring heart rate on convalescing heart attack patients has been routine for some time. However, most therapists manually record pulse rate before exercise and again after exercise at prescribed intervals. There has been and is a definite need for a small, inexpensive beat-to-beat cardiometer that will provide continuous heart rate information on exercising individuals with a concomitant time saving for therapists.

A portable unit was designed and fabricated with discrete components fashioned after a more sophisticated NASA unit which meets most of the needs of the problem originator. Those requirements, not filled would double the cost destroying the most desirable features of the instrument. The instrument will accept either electrodes or auxillary inputs and provides both meter and recorder outputs. The AEB-2 model incorporates telemetry features at a small increase in cost.

Brief Technical Description of the  
Portable Beat-to-Beat Cardiometer

This instrument has the ability to monitor ECG biopotentials either directly via electrodes or from auxillary devices such as tape recorders, telemetry systems, and chart recorders. The entire system fits nicely into a small case with a shoulder strap for ambulatory use. Further miniaturization is possible but for cost effective design, the prototypes were not reduced to a hand-held unit.

The instrument includes three subsystems depending upon design requirements:

1. Cardiometer
2. Transmitter
3. Demodulator

For the telemetry requirement a standard broadcast FM receiver is the only additional item required.

The cardiometer receives ECG biopotential signals, recognizes the R wave and squares it. A FET and reed relay comprise a sample and hold circuit which drives the meter and the output with a staircase signal.

The telemetry option provides a clinical ECG at point A on the schematic.

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## I. Introduction

The portable cardiometer was developed for therapists working with cardiovascular patients when it became obvious to both the therapists and the BATeam that commercially available devices were not available regardless of advertising claims.

Since rehabilitation money is scarce and the need great, an inexpensive system was definitely most desirable. While most problem originators desired high accuracy, high-low reading meters and hand-held devices, these features so increased the cost so as to diminish the effectiveness of an inexpensive device.

After careful analysis of five years of problems relating to cardiometer oriented solutions, the following design goals were chosen:

- 1) Heart rate must be measured accurately on both a meter and auxillary output.
- 2) Instrument is portable and durable.
- 3) Instrument should have a calibration range of 50-140 beats per minute (BPM).
- 4) Instruments should be versatile in type of inputs, electrodes, recorder, telemetry, etc.

Final design criteria included technology from MSFC on beat to beat cardiometers, ARC on biotelemetry, and SwRI state-of-the-art engineering techniques in combining all technology into an instrument providing reliable heart rate information.

A convenient size was chosen to package the device both for the standard unit and the telemetry unit primarily to remain cost effective. If unique applications arise, the device can easily be miniaturized into a hand-held device.

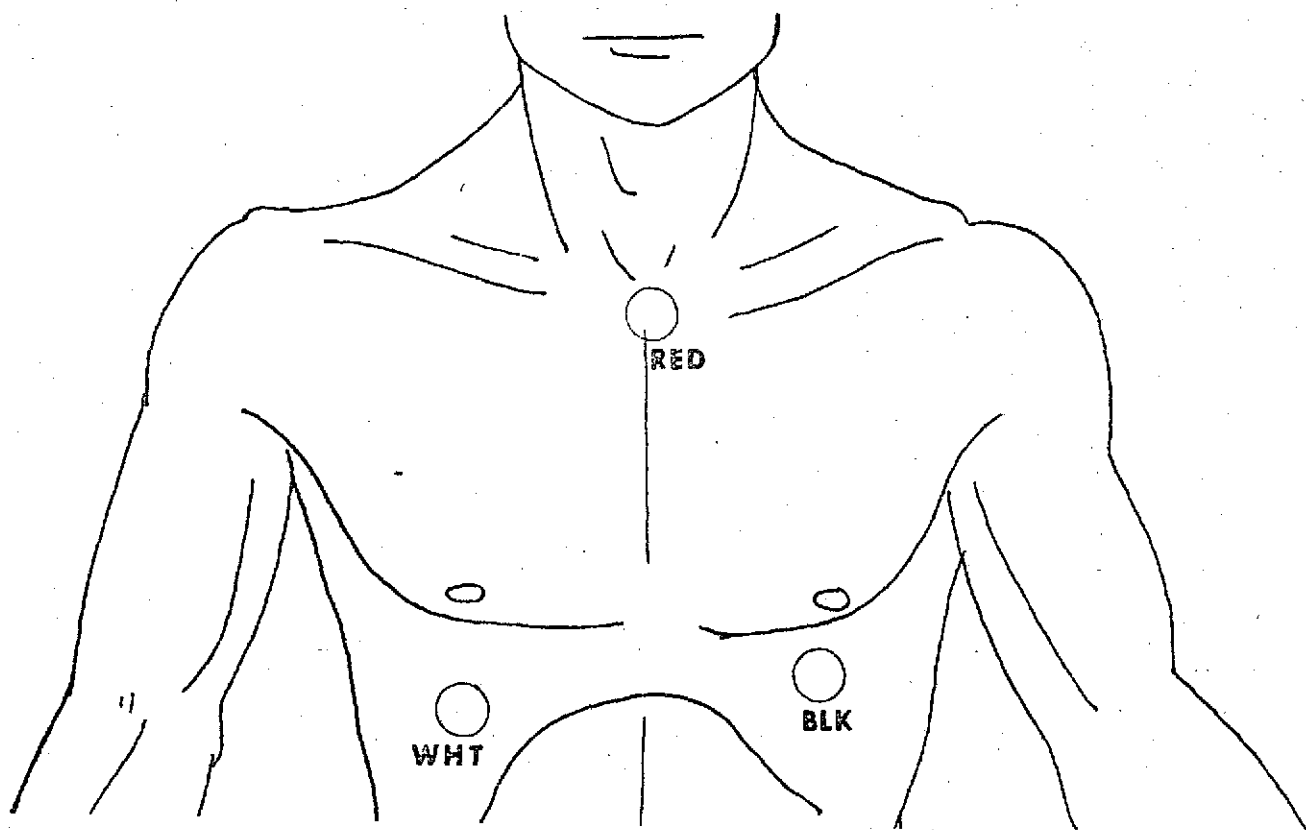


Figure 1(A) Electrode Placement (Hard Wire)

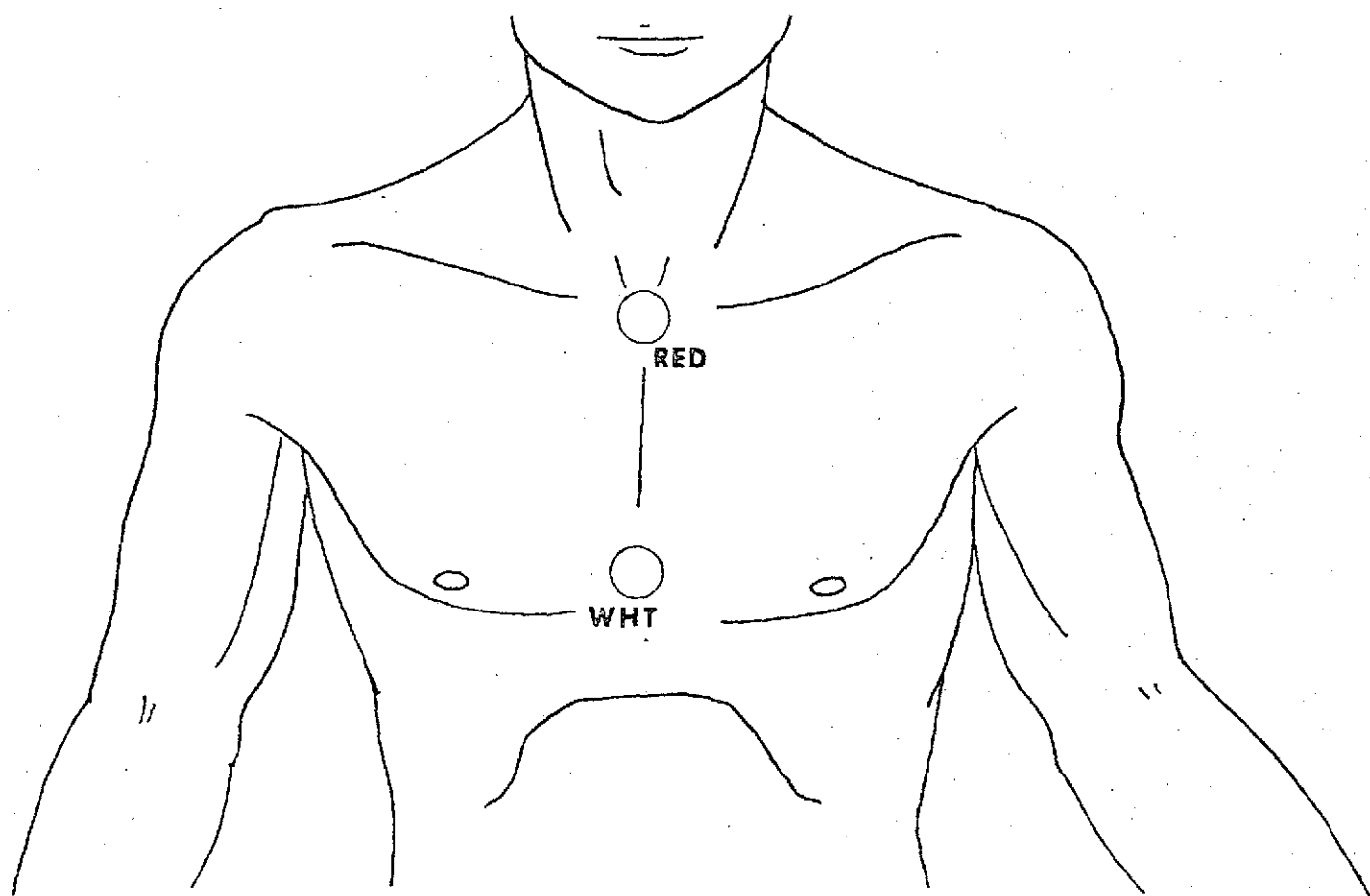


Figure 1(B) Electrode Placement (Telemetry)

## II. Operating Instructions

Acquiring heart rate information from electrodes is accomplished by connecting the electrodes to the patients as shown in Figure 1(A). Lead color is connected to the corresponding coded input jacks on the cardi tachometer. The selector switch is switched toward the electrode jacks and the unit is turned on. The instrument is now ready for use.

If heart rate information is being analyzed from a tape recorder or some other piece of auxillary equipment, the selector switch is switched toward the pulse position and a cable is attached to the pulse in jack.

Monitoring by telemetry is accomplished by placing the electrodes on the patient as shown in Figure 1(B) and the corresponding color coded wires connected to the transmitter. An FM standard broadcast receiver is tuned until a clear Heart Rate signal is acquired. The selector switch is switched to Pulse and a cable is connected from the earphone jack on the FM radio to the radio input on the cardi tachometer. The unit is now ready for use.

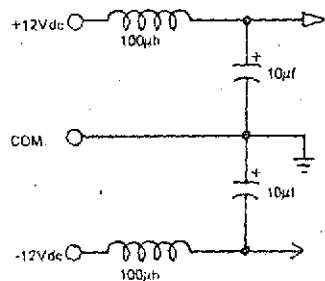
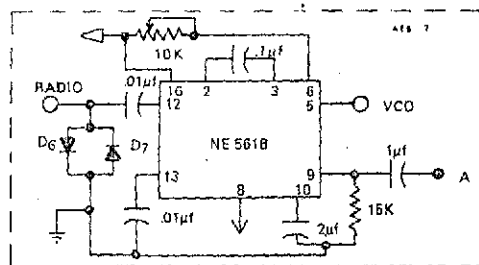
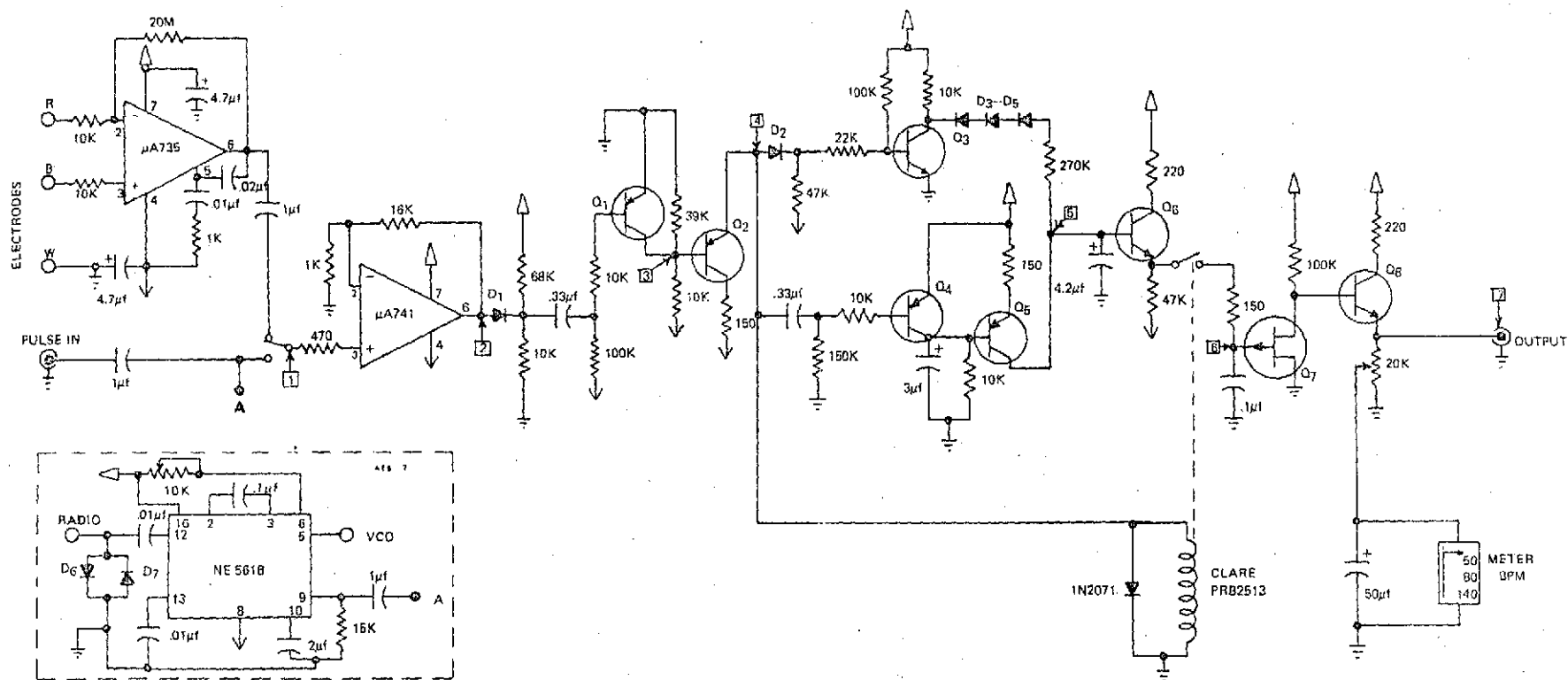
If visual readout other than the meter is desired, a cable may be connected from the OUTPUT jack to a suitable presentation device such as a strip chart recorder or oscilloscope.

## III. Technical Discussion

This cardi tachometer, a low cost solid state instrument, provides an output voltage proportional to the instantaneous frequency of ECG pulses in. Output linearity is  $\pm 5\%$  from 30 to 150 beats per minute with either hard wire or telemetry input. The meter is calibrated from 40-140 beats per minute.

The monitoring of heartrate on a beat-to-beat basis is facilitated by converting pulse interval to a voltage by means of an exponential waveform generator.

Operation of the cardi tachometer can best be described with the aid of the schematic, Figure 2. Depending on the input, the ECG is amplified by either the micropower input amplifier, the signal conditioner



—LEGEND—  
 Q<sub>1</sub>, Q<sub>2</sub>, Q<sub>4</sub>—2N1305  
 Q<sub>3</sub>—2N3904  
 Q<sub>5</sub>—2N3638  
 Q<sub>6</sub>, Q<sub>8</sub>—2N3565  
 Q<sub>7</sub>—2N4360  
 D<sub>1</sub>—D<sub>7</sub>—1N645

CARDIOTACHOMETER	
SCHEMATIC	
ENGR.	R. L. WILBUR
TECH.	M. C. HANZ
PROJECT:	BAT IVA 2 & AEB 2

amplifier (A 741) or the demodulator (NE561B). Waveform 2 is indicative of the positive pulse needed to drive the cardiometer section. Transistors  $Q_1$  and  $Q_2$  comprise a simple monostable multivibrator. The positive input pulse passed through  $D_1$  turns  $Q_1$  off, driving the emitter of  $Q_2$  to approximately -9 volts. This energizes the relay so that the 0.1 microfarad capacitor in the gate circuit of the FET is charged to approximately the same voltage as that of the 4.2 microfarad capacitor by means of emitter follower  $Q_6$ . During this sampling interval  $Q_3$  is off preventing the 4.2 microfarad capacitor from discharging through the 270 k ohm resistor. During this sampling interval, the .33 microfarad capacitor in the base of  $Q_1$  charges negatively turning  $Q_1$  on. The positive transition on the emitter of  $Q_2$  drives  $Q_4$  off and  $Q_5$  on.  $Q_4$  and  $Q_5$  is a monostable multivibrator like  $Q_1$  and  $Q_2$ . As  $Q_5$  turns on, the 4.2 microfarad capacitor charges rapidly to approximately +11 volts. The .33 microfarad capacitor in the base of  $Q_4$  charges negatively turning  $Q_5$  off so that the 4.2 microfarad capacitor may discharge through the 270 k ohm resistor.

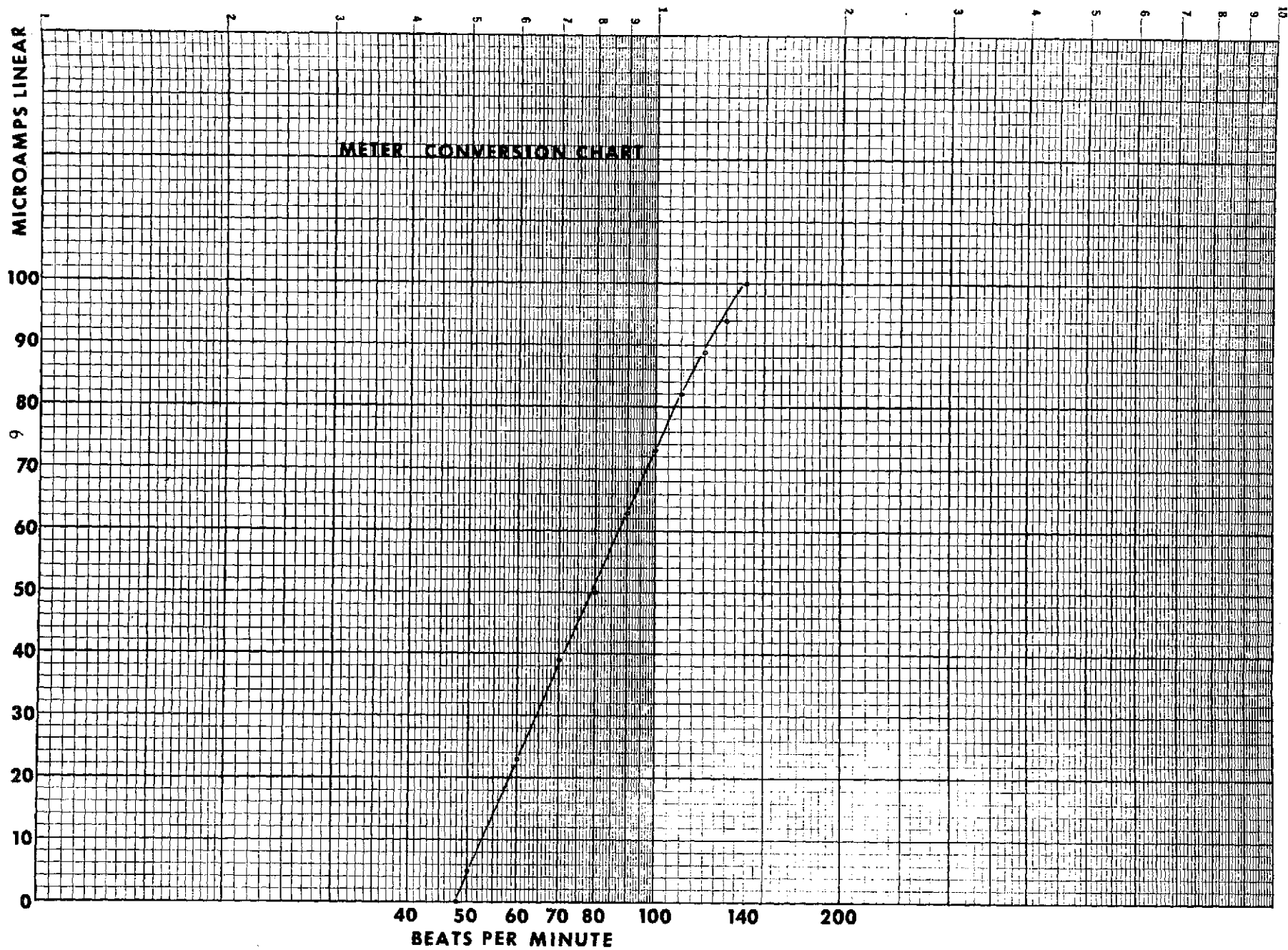
$Q_7$  and  $Q_8$  buffer the signal from the .1 microfarad capacitor to provide a low impedance output. The 20 k ohm potentiometer permits calibration of the meter.

Each succeeding pulse triggers the events described above so the output voltage is proportional to the reciprocal of the time between the most recent pair of pulses.

#### IV. Summary

Since the exponential discharge of the 4.2 microfarad capacitor and the 270 k ohm resistor approximates a hyperbola, the output is linear only from 30 to 150 beats per minute. To further improve linearity, this device is calibrated from 40 to 140 beats per minute. Figure 3 is a conversion chart for calibrating a linear meter to the exponential output. Layout and fabrication is not critical and due to the digitizing effect of the monostable multivibrators, noise other than faulty electrode application is not a problem.

Figures 4 and 5 show the layout and auxillary telemetry units.





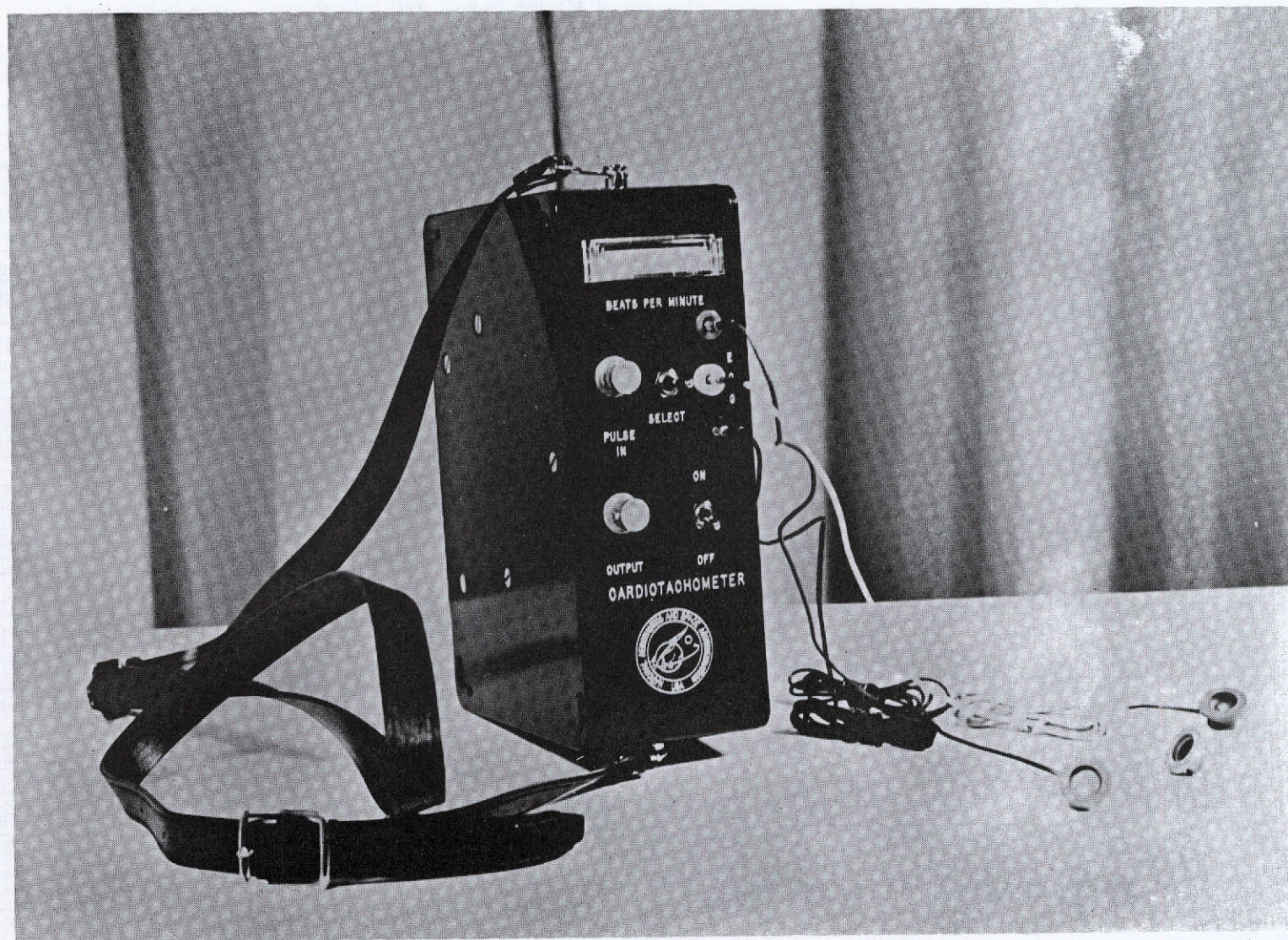


Figure 4(A) Instrument



Figure 4(B) Instrument

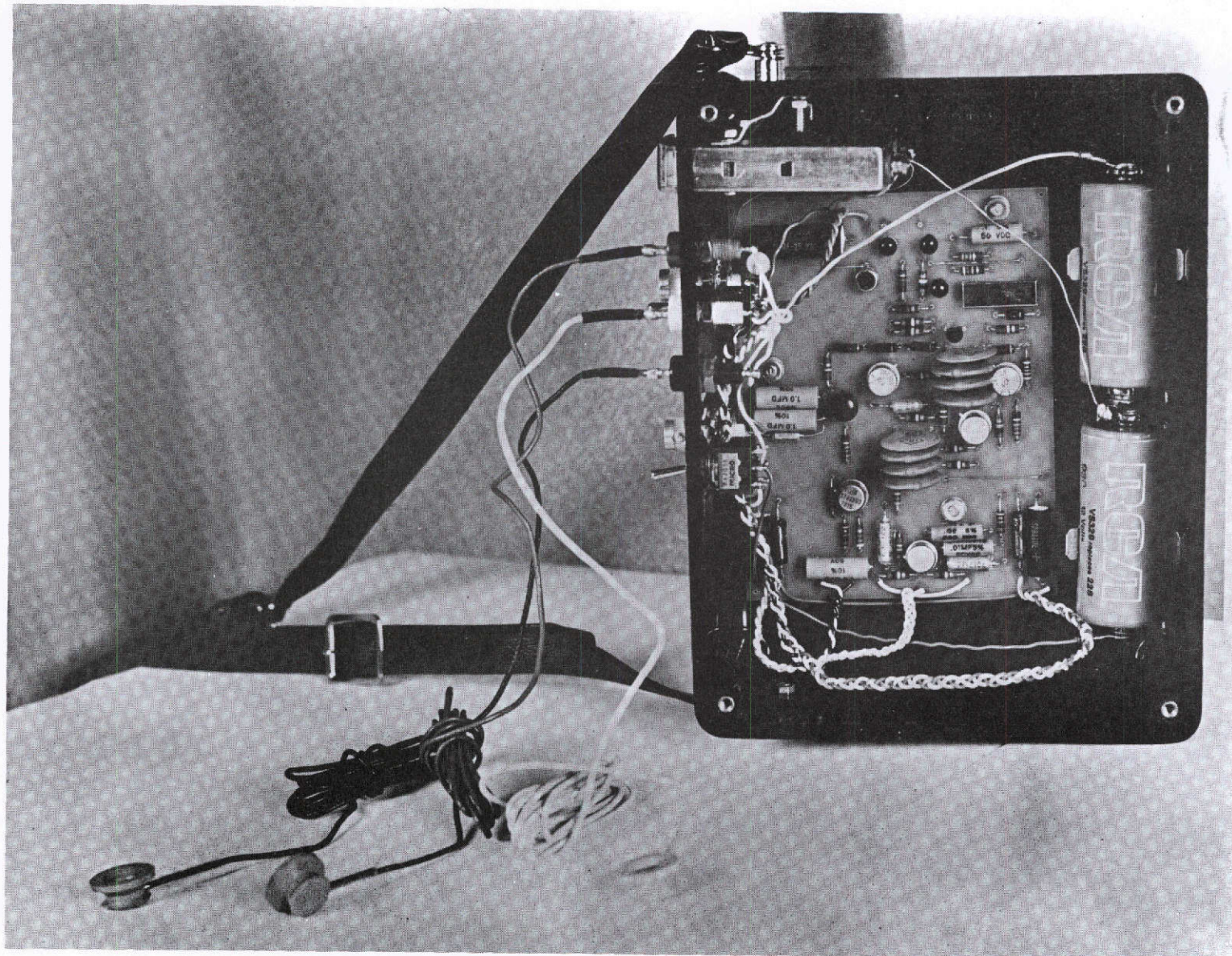




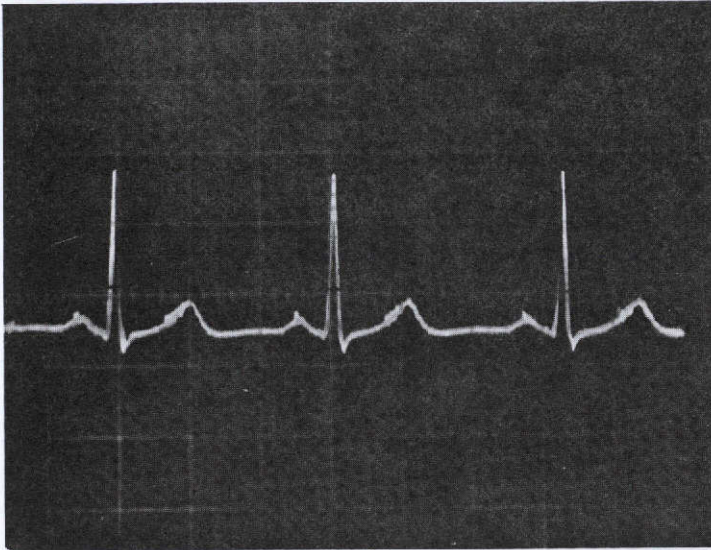


Figure 5 Telemetry

## APPENDIX A

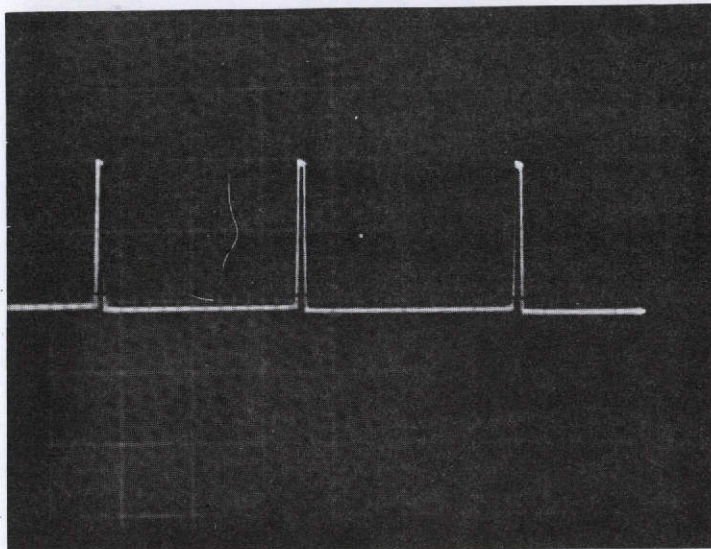
### WAVEFORMS





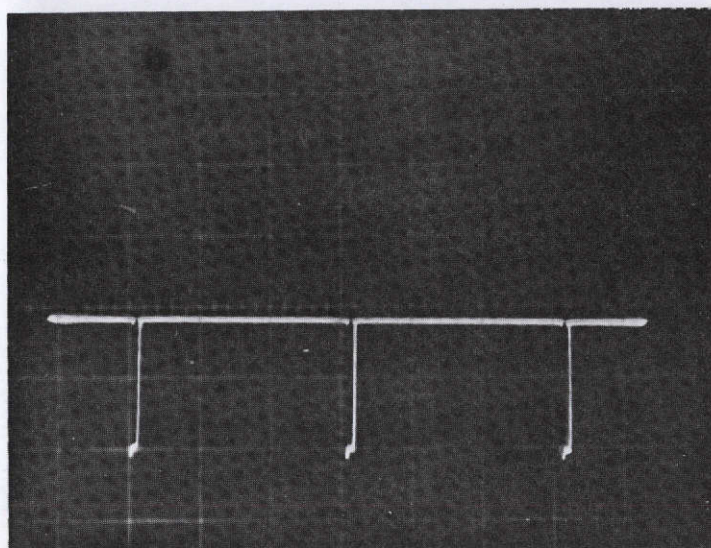
1 ECG or PULSE

VOLTS 2Volts/Cm  
TIME .2Sec/Cm



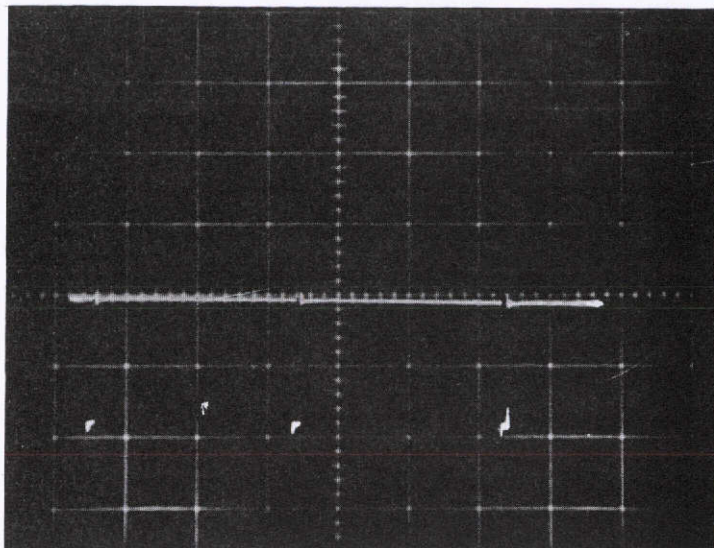
2

VOLTS 10Volts/Cm  
TIME .2Sec/Cm



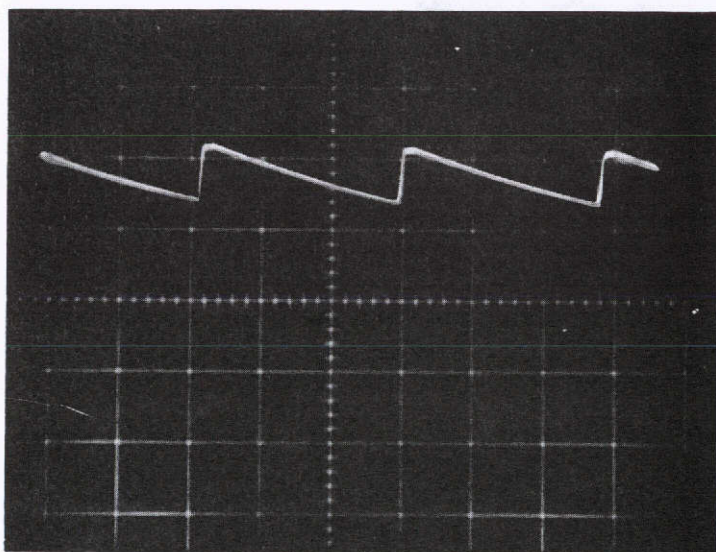
3

VOLTS 5Volts/Cm  
TIME .2Sec/Cm



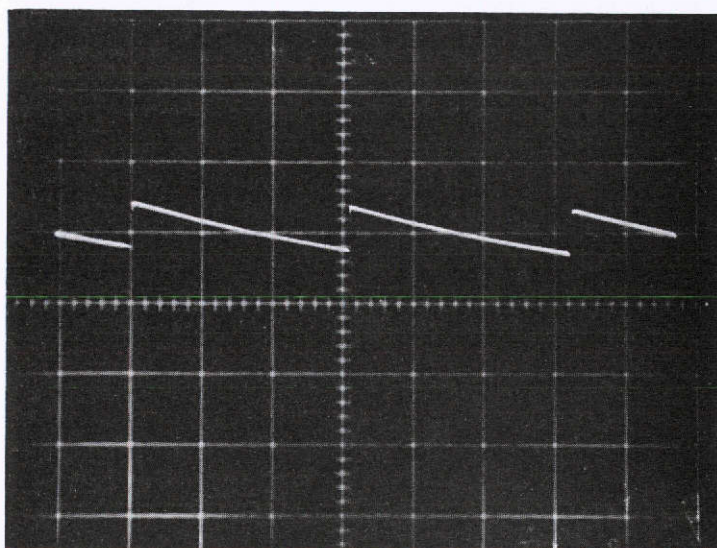
4

VOLTS 5Volts/Cm  
TIME .2Sec/Cm



5

VOLTS 5Volts/Cm  
TIME .2Sec/Cm

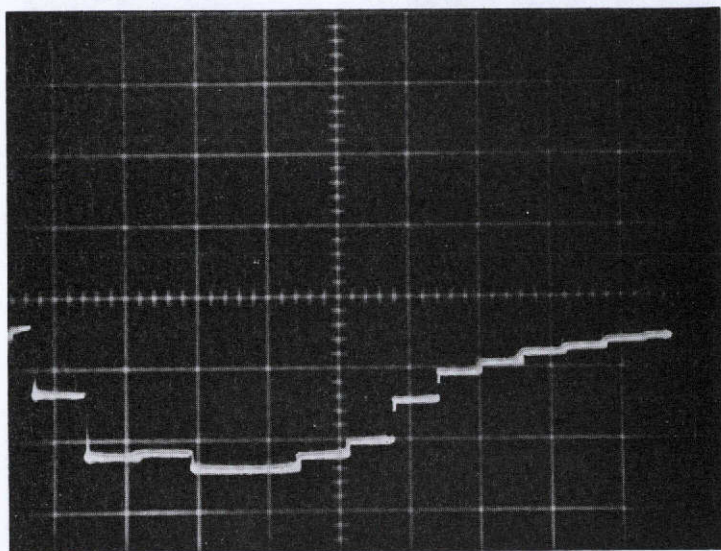


6

SAMPLE AND HOLD

VOLTS 5Volts/Cm  
TIME .2Sec/Cm





7 OUTPUT

VOLTS 5Volts/Cm  
TIME .2Sec/Cm

## APPENDIX B

### PARTS LIST

## TVA-2/AEB-2 CARDIOTACHOMETER

## Parts List

Integrated Circuits	Resistors (1/4W)	Capacitors (mfd)
Fairchild $\mu$ A 735 - 1	150 - 3    39K - 1	.01-1
Fairchild $\mu$ A 741 - 1	220 - 2    47K - 2	.02-1
Semiconductors	470 - 1    68K - 1	.1-1
2N1305 - 3	1K - 2    100K - 3	.35-2
2N3565 - 2	10K - 8    150K - 1	1.0-4
2N3638 - 1	16K - 1    270K - 1	Polarized
2N3904 - 1	22K - 2    20M - 1	3.0-1    4.7-2
2N4360 - 1	Potentiometer	10.0-2    50.0-1
Diodes	20K - 1 (pc mounted)	
IN645 - 5		
IN2071 - 1	RF Chokes - 100 $\mu$ h - 2	Relay - 1 Clare PRB 2513
Switches	Batteries	Meter
SPDT - 1 (Select)	Burgess PM 8 - 2	100 na dc
DPST - 1 (Power)	12v	Weston Mod 111
	Holder	Enclosure
Connector		Davies 260
ECG - 3 Johnson Jax		Instrument Case
Pulse - BNC		
Out - BNC		

## AEB-2 DEMODULATOR

## Parts List

Integrated circuits  
Siliconix NE561B PPL-1

Diodes  
1N645 - 2

Resistors  
15K - 1

Capacitors (mfd)  
.01 - 2 ea  
.1 - 1 ea  
1 - 1 ea  
2 - 1 ea

Potentiometer  
10 k - 1 ea

## APPENDIX C

### BOARD LAYOUT



TVA 2 :: AEB 2  
CARDIOTACHOMETER

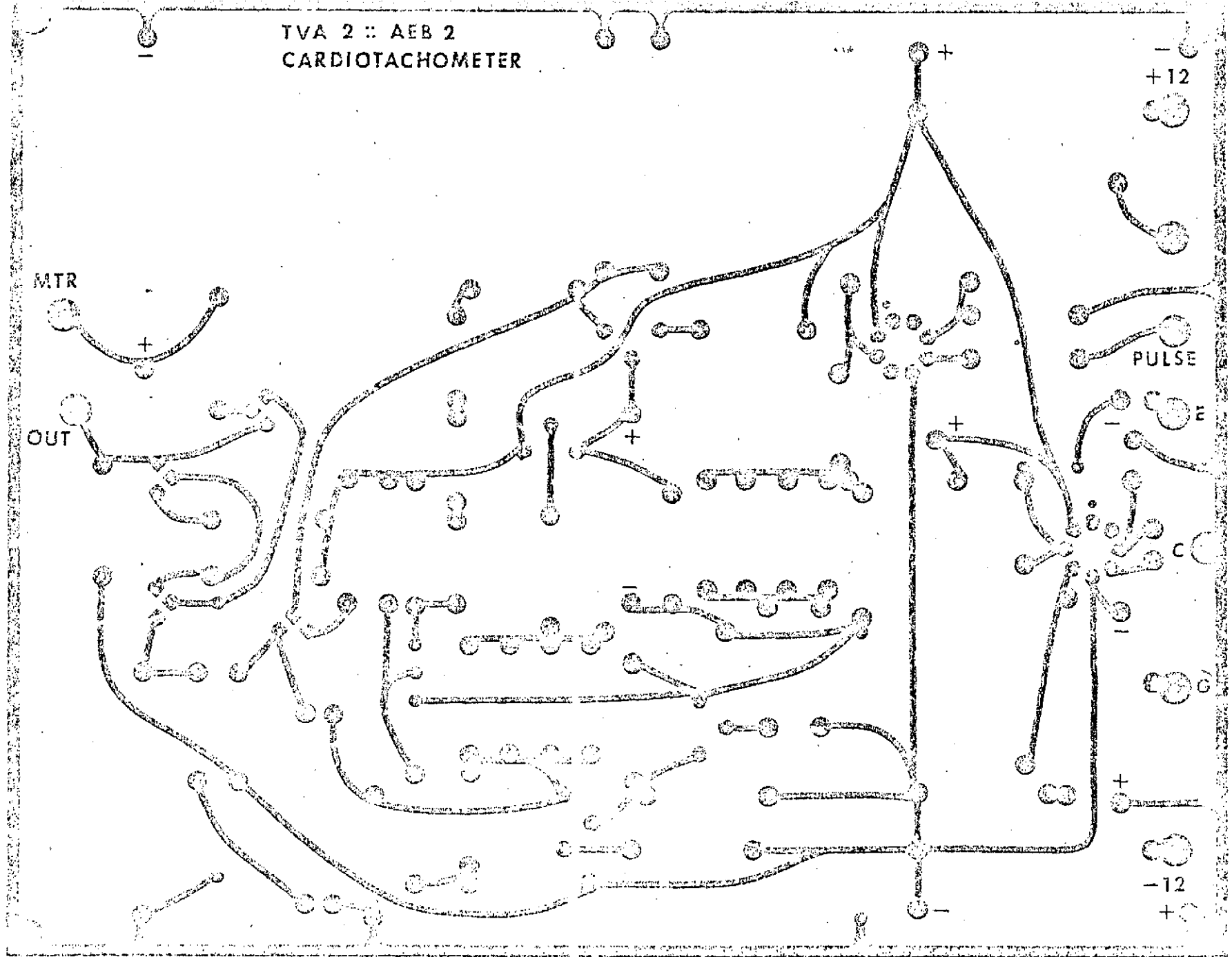
MTR

OUT

PULSE

+12

-12



TECHNOLOGY APPLICATION REPORT

Problem: AEB-3 LIGHT SENSITIVE VOCATIONAL  
REHABILITATION AID

Institution: Arkansas Enterprises for the Blind  
P. O. Box 4055, Asher Ave. Station  
Little Rock, Arkansas 72204

Investigator: Elmo Knoch  
Director of Training

Acquisition Date: June, 1972 Completion Date: August, 1973

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#### PROBLEM OBJECTIVE

A hands-free device was needed which would allow a blind PBX operator to distinguish between bright red and white lights on a switchboard.

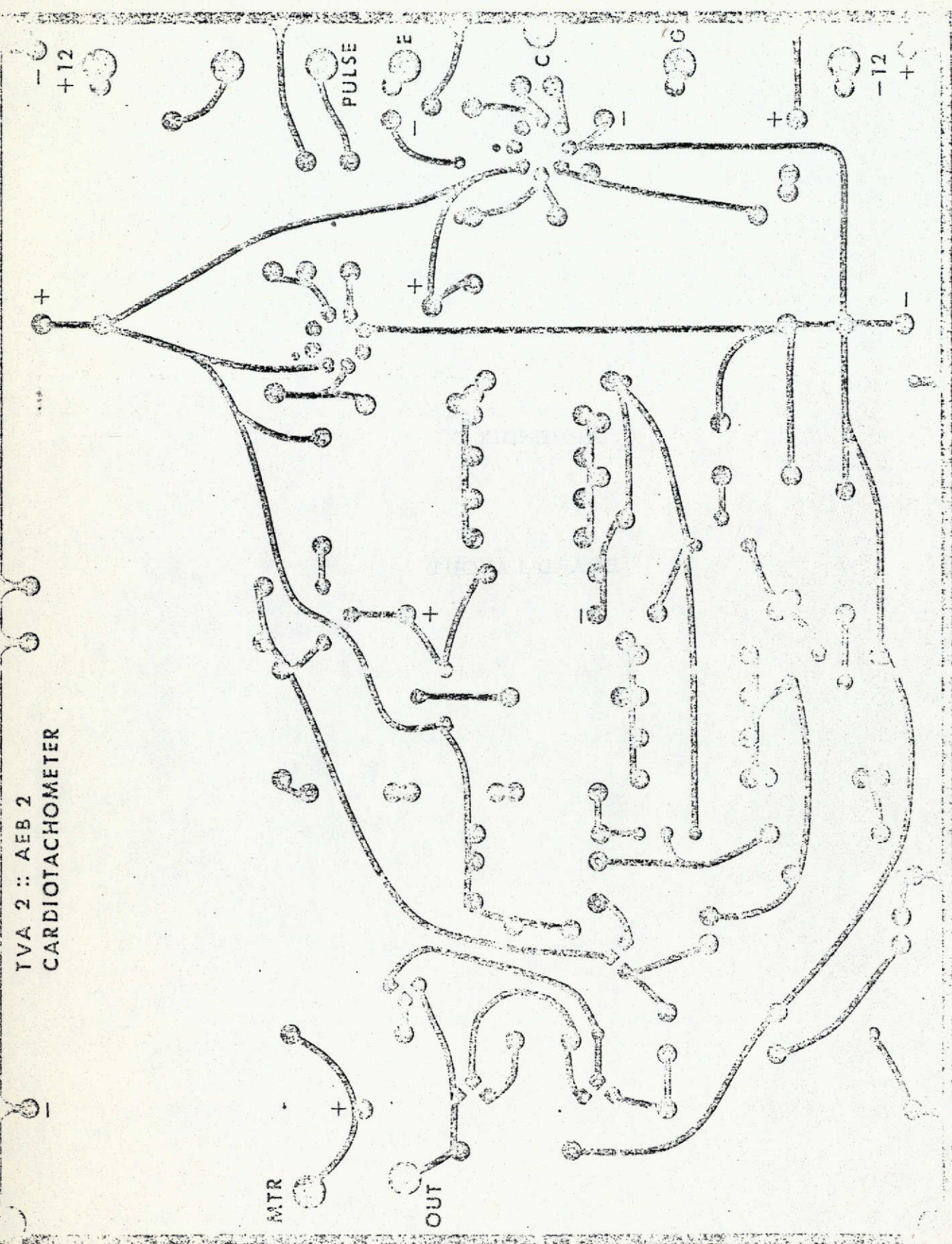
#### BACKGROUND

Vocational instructors of a rehabilitation center expressed a need for a hands free, light sensitive, lightweight device which would allow a blind telephone operator to operate a PBX switchboard. The investigator envisioned a pocket-size electronic device with a ring mounted light probe which, when worn by the operator, would emit a tactile output, thus eliminating the need for an audio signal which would disturb an office environment. A variation of this device would incorporate a small receiver interfaced to the telephone headset so that the light signal from the switchboard would be transformed into a signal heard only by the operator.

#### RESOLUTION

The investigator provided a basic design through the BATeam to Mr. Billy G. Holliday at Langley Research Center for concept and fabrication of a working prototype. The Light Sensitive Rehabilitation Aid employs a photoelectric cell to control the trigger level of a voltage controlled oscillator. This oscillator drives an audio amplifier and ear phone producing a sound proportional to the intensity of the light source. An increase in light intensity produces a corresponding increase in the frequency of the sound. Volume control is independent of frequency. Sensitivity and threshold controls are employed to adjust the range of the oscillator to suit various light

TVA 2 :: AEB 2  
CARDIOTACHOMETER



intensities and background light levels.

It should be noted here that the prototype unit was not optimized, but was assembled to determine the feasibility of the concept. Use of micro-electronics in the system could substantially reduce the size.

#### APPLICABLE NASA TECHNOLOGY

Work done at the NASA Centers is applicable by nature of its place of origin. A Technical Support Package has not been written at this feasibility stage, however, operating instructions for the device and relevant schematics follow this summary.

#### EVALUATION

The device was forwarded to the investigator in the middle of August, 1973, hence, not enough time has elapsed for suitable evaluation. However, initial reports state that the device seems to be working well and that the design is feasible enough to consider it a real solution to the original problem.

# OPERATING INSTRUCTIONS for AEB-3 LIGHT SENSITIVE VOCATIONAL REHABILITATION AID

## THEORY OF OPERATION

The Light Sensitive Vocational Rehabilitation Aid employs a photoelectric cell to control the trigger level of a voltage controlled oscillator. This oscillator drives an audio amplifier and ear phone (or speaker) producing a sound proportional to the intensity of the light source. An increase in light intensity produces a corresponding increase in the frequency of the sound. Volume control is independent of frequency. Sensitivity and threshold controls are employed to adjust the range of the oscillator to suit various light intensities and background light levels.

## OPERATING INSTRUCTIONS

Fixed light intensities can produce different frequencies depending on the setting of the sensitivity and threshold controls. The user should become familiar with the function and effect of these controls using known light intensities.

The effect of the threshold control can be realized by selecting a medium sensitivity setting, placing the light probe against a light source and varying the threshold control. The oscillator should be turned on or off as you vary the control. The effect of the threshold control can be eliminated by covering the photocell and adjusting the control until no sound is produced.

Fixed light intensities can produce different output frequencies depending on the setting of the sensitivity control. This can be realized by placing the probe against a fixed light source and varying the sensitivity control. Be sure the threshold is not set above the light source--set the threshold control so the oscillator is just turned off.

## ADJUSTING THE CONTROLS TO DETERMINE DIFFERENCES IN SEVERAL LIGHT SOURCES

Select a medium sensitivity setting and adjust the threshold (with the probe exposed to the background light) until no sound is produced. Place the probe against one of the light sources and increase the sensitivity until sound is produced. Determine which one of the sources produces the lowest tone, then select a sensitivity setting that will just produce sound when the probe is placed against this source. It may be necessary to adjust the sensitivity and threshold controls several times to find the settings that produce the greatest change in sound.

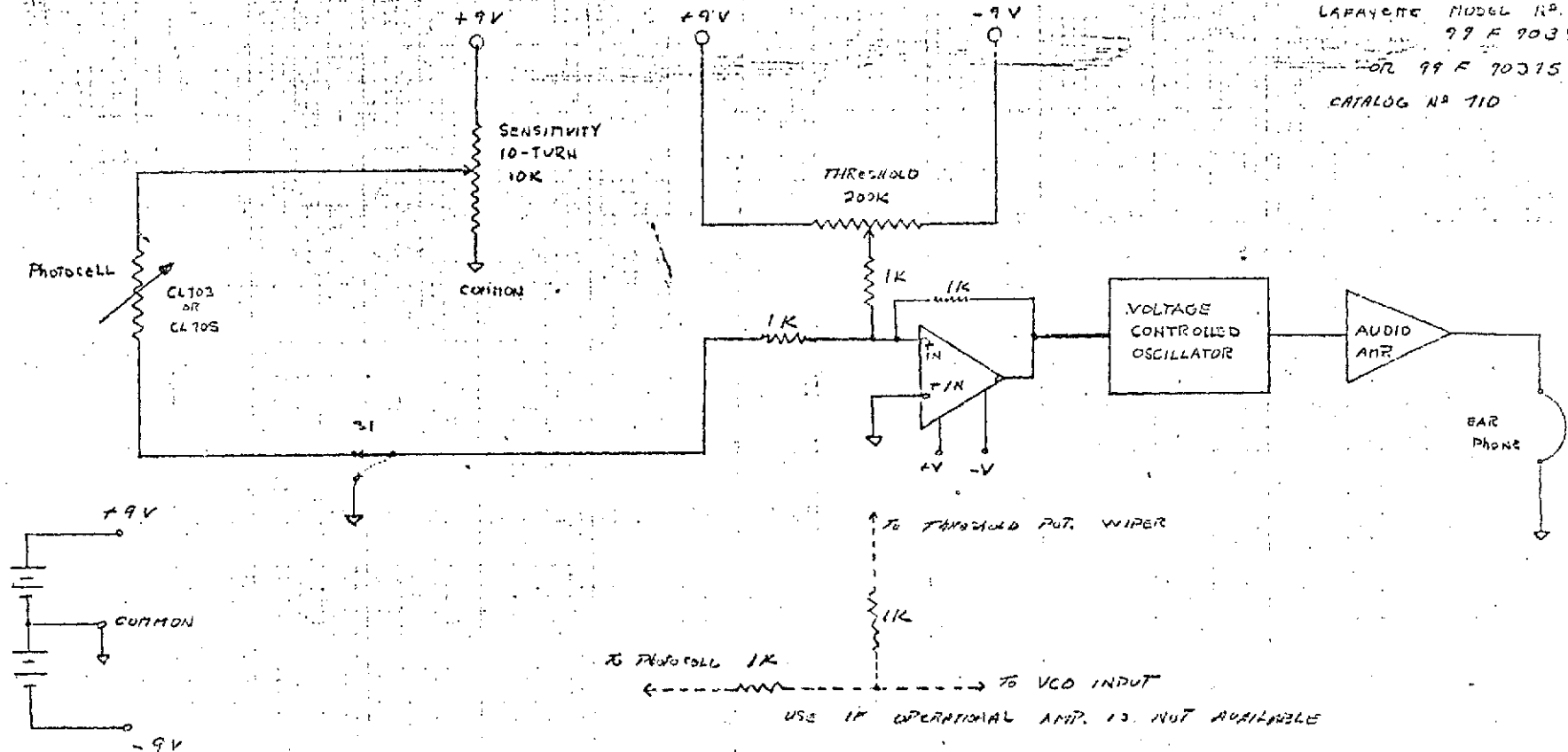
# LIGHT SENSITIVE REHABILITATION AID - AEB-3

AUDIO AMP - ANY LOW POWER (1WATT) AMPLIFIER

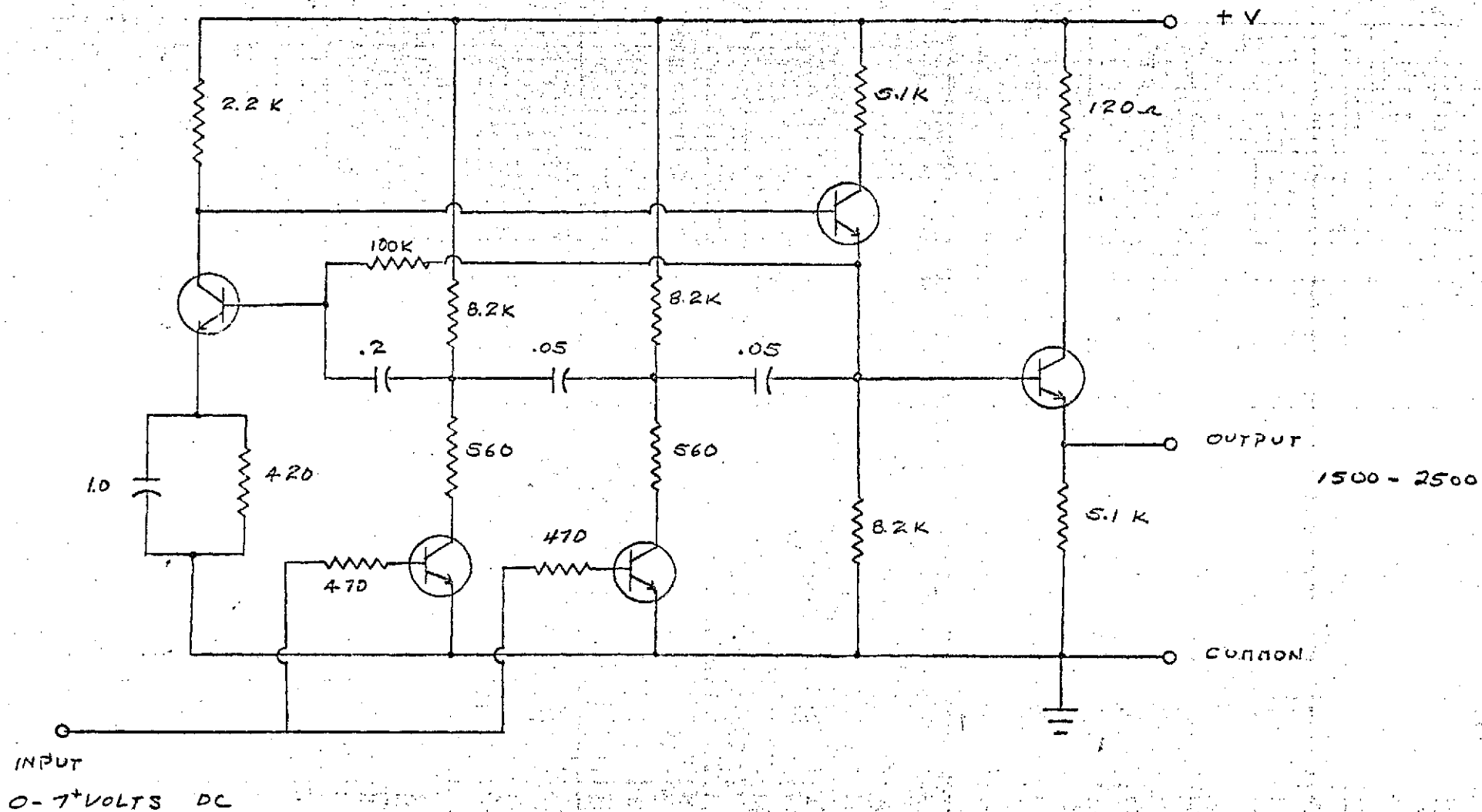
LABAYONE MODEL NO. 99 F 70391

FOR 99 F 70315

CATALOG NO 710



MATERIAL	SCALE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LANGLEY RESEARCH CENTER LANGLEY STATION HAMPTON, VIRGINIA 23365
TOLERANCE ON DIMENSIONS (UNLESS SHOWN OTHERWISE)	X.X (1 DECIMAL PLACE) ±.1	



VOLTAGE CONTROLLED OSC.

(LIGHT SENSITIVE IRRADIATION AID - AEB-3)

ALL TRANSISTORS - 2N1302 OR ANY LOW POWER NPN



## TECHNOLOGY APPLICATION REPORT

Problem: AEB-4 APPARATUS FOR MEASURING TACTILE  
SPATIAL SEPARATION

Institution: Arkansas Enterprises for the Blind  
P. O. Box 4055, Asher Ave. Station  
Little Rock, Arkansas 72204

Investigator: Elmo Knoch  
Director of Training

Acquisition Date: June, 1972 Completion Date: September, 1973

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### PROBLEM OBJECTIVE

Investigators needed an improved method and/or device to measure cutaneous sensory perception in their blind patients to help evaluate them for predicting ability to read braille as well as determining hypothesia for basic medical reasons.

### BACKGROUND

Determinations of various diseases, examinations for treatment of nervous disorders, and evaluation of finger-touch sensitivity for blind persons have all been related to aesthesia, or skin sensitivity to pain. Measurement or detection of cutaneous perception has not heretofore been quantified, because of the lack of an instrument capable of consistently reproducing measurements. Most devices employed to date have included the use of a sharp pin or a plurality of pins of differing sharpness and cross sectional areas. The pin or pins have been brought into contact with the skin by the medical examiner while observing the response of the patient. Because of the different muscular coordination by different examiners, the resulting pin strikes lack any of the requisite uniformity and it has therefore been exceedingly difficult for even the individual examiner to contact the skin with a consistent degree of pressure. Because of these methods, differences in cutaneous perception measurements lack reliability and therefore may not be due to the health condition of the patient.

### RESOLUTION

A directly applicable NASA Tech Brief was located and up-to-date technological information was gathered. The resulting design modifications to the original NASA device were a result of cooperation between SwRI and the NASA exclusive manufacturer licensee. The improved aesthesiometer device is designed to



deliver a repeatable and determinable pressure to the skin of the individual. In addition, that pressure is independent of the relative condition of muscular coordination of the examiner. The device is reliable, non-invasive and non-injurious, of relatively simple construction, and can be effectively operated in research or clinical practice by any technician. Briefly, the device comprises a method utilizing a flexible but stiff nylon monofilament stimulating element which is telescopically enclosed in a tubular housing. Affixed within the housing and operatively coupled to the stimulating element is a screwdrive mechanism which is in turn coupled to a vernier counter adjustment on the exterior of the housing. Observation of the vernier counter adjustment at the point of sensory perception by the individual indicates an absolute value for cutaneous response.

#### APPLICABLE NASA TECHNOLOGY

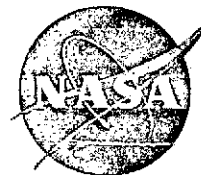
The original device was developed under NASA Contract by General Electric and was located and described in NASA Tech Brief B72-10032. Exclusive manufacturing rights to the device have been given to Rowan Products Company, 14535 Saticoy Street, Van Nuys, California 91405. A Technical Support Package for the device will be available soon. A technical design sketch of the aesthesiometer follows this summary.

#### EVALUATION

Device was in process of final calibration and delivery at contract termination, therefore, sufficient time for extensive evaluation has not elapsed.

# NASA TECH BRIEF

## *Manned Spacecraft Center*



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### An Improved Aesthesiometer

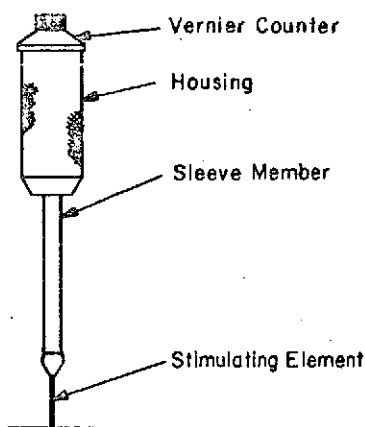


Figure 1.

An improved biomedical tool measures cutaneous sensory preception with improved reliability and consistency. A vernier-adjustable, monofilament stimulating element is pressed against the skin. The force necessary to produce a slight element flexure is inversely proportional to the element length and is indicated by the calibrated vernier dial.

Previously, examiners noted the patient's responses to touches with a series of pins, but were not able to take actual measurements of the pressure applied. The improved aesthesiometer allows consistent application of a regular and determinable pressure to the skin of the individual. It is of relatively simple construction, inexpensive to manufacture and easy to operate.

The instrument (illustrated in Figure 1) is basically a thin stimulating element attached to a calibrated vernier dial. Adjustment of the dial extends or retracts

the element within a tubular sleeve. In use, the element is brought into contact with the subject and pressed against the skin until a slight element flexure is noted. If the patient does not respond, the element is shortened to make it stiffer and the process repeated until the pressure is felt. This contact pressure is determined from the dial setting by reference to a calibration curve (illustrated in Figure 2).

#### Note:

Requests for further information may be directed to:

Technology Utilization Officer  
Manned Spacecraft Center, Code JM7  
Houston, Texas 77058  
Reference: TSP72-10032

(continued overleaf)

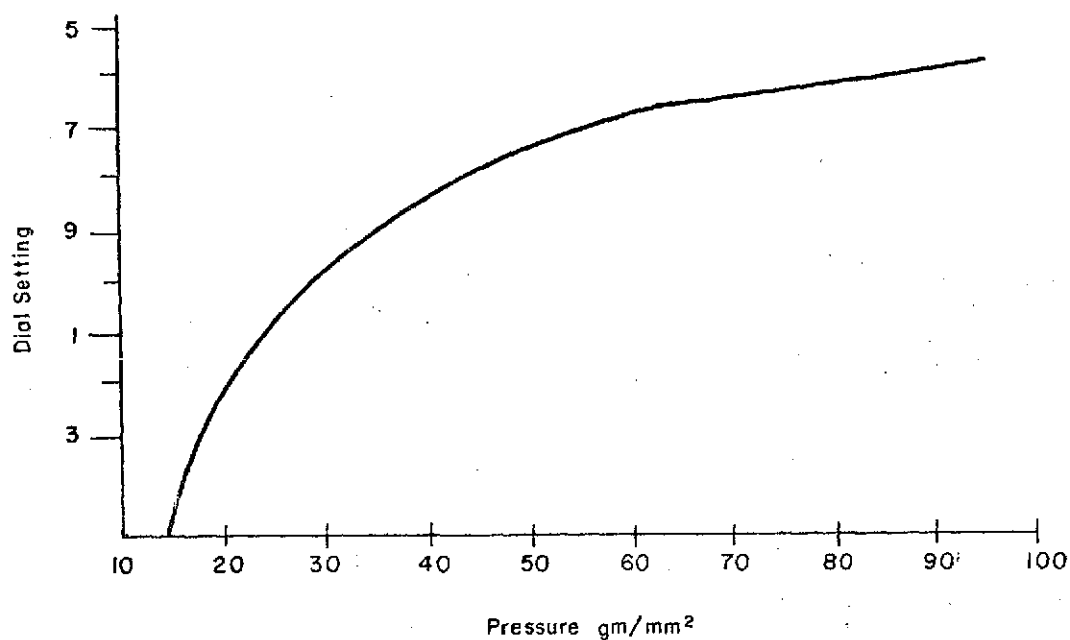


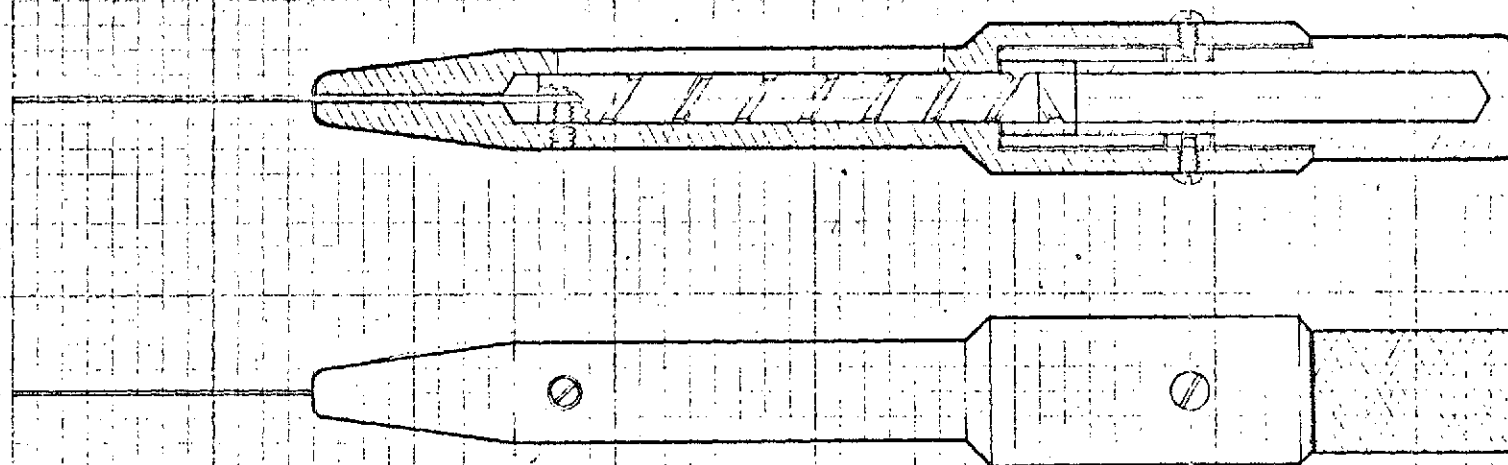
Figure 2.

**Patent status:**

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to:

Patent Counsel  
Code AM  
NASA Manned Spacecraft Center  
Houston, Texas 77058

Source: D. Wright and R. Richardson  
General Electric Company  
under contract to  
Manned Spacecraft Center  
(MSC-13609)



AESTHESIOMETER DEVICE  
NASA/BAT PROB. AEB-4

TECHNOLOGY APPLICATION REPORT

Problem: CRH-8 WEIGHT SHIFT ALARM FOR BRAIN DAMAGED  
AND PARAPLEGIC PERSONS

Institution: Craig Rehabilitation Hospital  
3425 South Clarkson  
Englewood, Colorado 80110

Investigator: Mr. Scott Manley  
Director of Family and Patient Services

Acquisition Date: March, 1973 Completion Date: August, 1973

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## PROBLEM OBJECTIVE

The investigator requested a method of teaching and/or reminding newly paralyzed persons to lean to periodically shift their sitting or reclining positions.

## BACKGROUND

A person sitting or lying down must occasionally shift his position to allow blood to flow to those points supporting his weight. Failure to do so will cause cell damage and eventually result in the development of decubitus ulcers. This is a particular problem to the paraplegic and brain damaged persons who no longer experience the feelings of discomfort which cause a normal person to occasionally change position. The Movement Monitor was developed to provide those patients with a periodic reminder of the need to alter their position.

## RESOLUTION

NASA Tech Brief B71-10437, "Externally Programmed Variable Timer," was identified and presented a basis for the solution device designed by the BATEam engineers.

In designing this device it was felt that the following criteria should be met: (1) to develop a device which would provide a periodic reminder to the patient of the need to move, and if possible, to require that he do so; (2) to make the device completely portable so that it could be used in a bed, wheelchair, or any other place the patient desires; (3) to provide ease of operation, long battery life and minimum maintenance requirements; and (4) to design a device which could be easily and inexpensively manufactured. Designing to these criteria resulted in a small, portable package containing

timing and control circuitry plus an audible alarm all powered by a single 9 volt transistor battery. The electronics are controlled by a pressure switch placed under the patient to sense his movement, or lack thereof, and accomplish the necessary alarm disable and/or circuit reset functions.

Much of the movement monitor logic was derived from similar devices developed by NASA, modified as necessary to meet the specific requirements of the problem. State-of-the-art electronics were incorporated where possible to minimize power requirements and the need for maintenance.

#### APPLICABLE NASA TECHNOLOGY

A copy of NASA Tech Brief B71-10437 follows this summary. A Technical Support Package has been written for the Movement Monitor and is included here.

#### EVALUATION

The Movement Monitor was put in use immediately with a former quadriplegic patient with very sensitive skin. The patient had had a history of several decubiti and needed to develop the habit of doing weight shifts every 15 minutes. The device had excellent results. Plans are underway to utilize the device for training of several other patients immediately.

# NASA TECH BRIEF

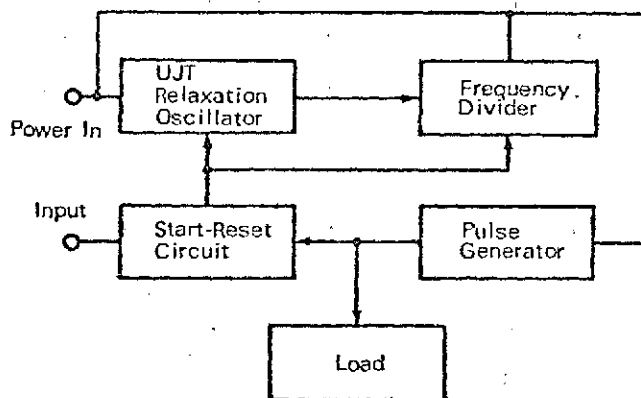
## Marshall Space Flight Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### Externally Programmed Variable Timer

A unique timing device, developed to satisfy 1-sec, 5-sec, and 10-min timing requirements, incorporates external programming capability.



Programmable Timer Block Diagram

Operational efficiency of  $\approx 5\%$  over a temperature range of  $-65^\circ\text{C}$  to  $+130^\circ\text{C}$  was a design requirement. To reduce the effect of temperature on the programmable timer, the time constant of the unijunction transistor (UJT) oscillator (see fig.) was reduced and the oscillator frequency was divided by using bistable multivibrators (flip-flops). This limited the temperature sensitivity of the timer to that of the UJT oscillator.

The number of flip-flops used at any given time is programmed by interconnecting the desired number of available inputs and outputs. The universal timer can divide the output frequency of the UJT

oscillator by 2, 4, 8, 16, 32, 64, or 128. Output of the final flip-flop is connected to a pulse generator circuit that produces a 28 V, 50 msec pulse. This output is routed back to a start-reset circuit that controls the UJT relaxation oscillator and the flip-flops.

Temperature and voltage range tests resulted in an accuracy of  $\pm 3.9\%$  with supply voltage variations of 24 to 31 Vdc over the temperature range of  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ . The programmable timer was within the  $\approx 5\%$  efficiency over the required temperature range with the same supply voltage regulation.

#### Note:

Requests for further information may be directed to:

Technology Utilization Officer  
Code A&TS-TU  
Marshall Space Flight Center  
Huntsville, Alabama 35812  
Reference: TSP71-10437

#### Patent status:

No patent action is contemplated by NASA.

Source: P.R. Gulbis of  
Sperry Rand  
under contract to  
Marshall Space Flight Center  
(MFS-20776)

Category 04

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MOVEMENT MONITOR

ABSTRACT

A continuing problem for partially and completely paralyzed persons is that of skin ulcerations caused by prolonged sitting or laying in one position. This problem is especially troublesome to the newly paralyzed who are not yet fully aware of the need to occasionally change positions so that blood can flow to those points of the anatomy supporting the body weight. The NASA Biomedical Applications Team at Southwest Research Institute developed the Movement Monitor in response to a request for a device which would remind paraplegic patients to occasionally move or shift their position to allow blood flow to the pressure areas. The device consists of a timing circuit and an alarm buzzer controlled by a pressure switch placed under the patient. Whenever the patient fails to move within a preset time period, the buzzer sounds, reminding him of the need to change positions. The alarm is disabled and the timing circuit reset by the patient's movement. Provision is provided to allow for the selection of the time period best suited to the requirements of the individual patient. It is felt that this device will contribute significantly to the comfort and rehabilitation of paraplegic patients.



## MOVEMENT MONITOR

### TECHNICAL BRIEF

The Movement Monitor was developed to meet the need for a device which would remind paraplegic patients of the need to occasionally change their position in order to avoid the occurrence of decubitus ulcers at those points of the anatomy supporting the body weight. The unit consists of a pressure sensitive switch placed under the patient, a variable delay timing circuit, and an alarm buzzer. If the patient does not move in a predetermined length of time, the buzzer will sound, reminding him of the need to alter his position. Movement will reset the timing circuit and alarm.

The timing circuit consists of a long time constant astable multivibrator, a presetable binary divider and the gating necessary to accomplish the alarm and reset operations. The output of the digital circuitry is applied to a transistor driven low current buzzer to provide the alert signal. The entire device is controlled by the patient seat switch which resets the circuit whenever the subject makes a sufficient movement.

The use of an astable timing circuit, while not a precision device, is sufficiently accurate for the needs of this application and allows the development of a much more inexpensive unit. The binary divider was included to provide a series of presetable time delays, ranging from 15 minutes to 2 hours in 15 minute intervals.

RCA COS/MOS digital logic integrated circuits were used to keep power requirements at a minimum. The Movement Monitor is powered by a standard 9 volt transistor battery with current requirements of approximately 0.5 milliamperes under normal operation, and less than 10 milliamperes under alarm conditions.

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II       Operating Instructions	3
III      Technical Discussion	8
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Appendix A - Parts List and Construction Suggestions	13

## LIST OF FIGURES

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Fig. 2    Front Panel	4
Fig. 3    Interior View	7
Fig. 4    Block Diagram	9
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## I. INTRODUCTION

A person sitting or laying down must occasionally shift his position to allow blood to flow to those points supporting his weight. Failure to do so will cause cell damage and eventually result in the development of decubitus ulcers. This is a particular problem to paraplegic and brain damaged patients who no longer experience the feelings of discomfort which cause a normal person to occasionally change position. The Movement Monitor was developed to provide those patients with a periodic reminder of the need to alter their position.

In designing this device it was felt that the following criteria should be met: (1) to develop a device which would provide a periodic reminder to the patient of the need to move, and if possible to require that he do so; (2) to make the device completely portable so that it could be used in a bed, wheelchair, or any other place the patient desired; (3) to provide ease of operation, long battery life and minimum maintenance requirements; and (4) to design a device which could be easily and cheaply manufactured. Designing to these criteria resulted in a small, portable package containing timing and control circuitry plus an audible alarm all powered by a single 9 volt transistor battery. The electronics are controlled by a pressure switch placed under the patient to sense his movement, or lack thereof, and accomplish the necessary alarm disable and/or circuit reset functions.

Much of the Movement Monitor logic was derived from similar devices developed by NASA, modified as necessary to meet the specific requirements of this problem. (See NASA Tech Brief B71-10437 "Externally Programmed Variable Timer"). State of the art electronics were incorporated where possible to minimize power requirements and the need for maintenance.



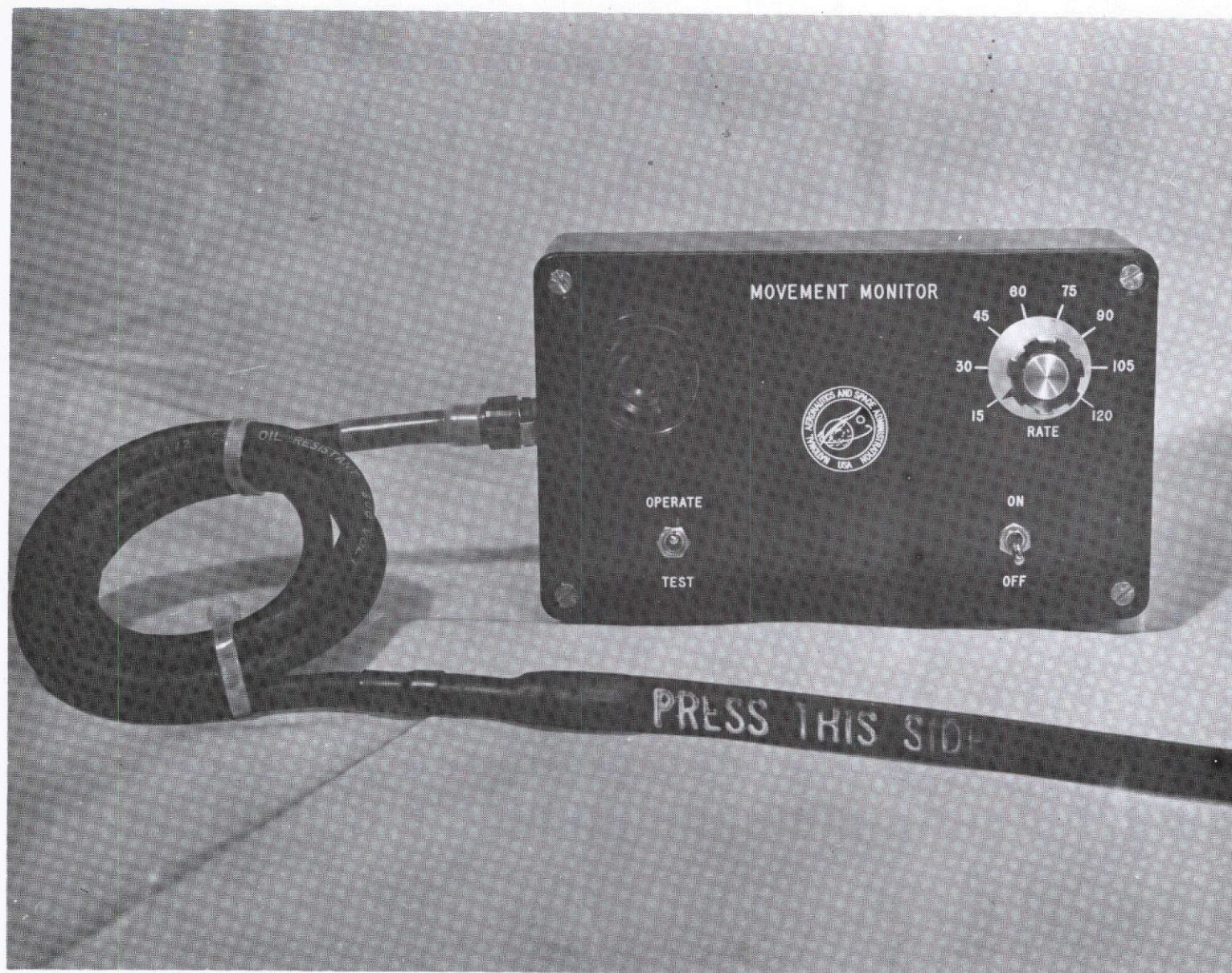


Figure 1 - MOVEMENT MONITOR



## II. OPERATING INSTRUCTIONS

The Movement Monitor is designed to provide maximum ease of operation and minimum maintenance. Once placed in operation, the user need only to shift his body weight to actuate the alarm disable and timer reset circuitry. Maintenance is limited to the occasional replacement of the standard 9 volt transistor battery which powers the device.

### Controls

Operation of the Movement Monitor is controlled through the following switches: (See Figure 2)

1. Power Switch - a single pole, single throw toggle switch located in the lower right-hand corner of the front panel. When placed in the "on" position, power is applied to the circuitry.
2. Test-Operate Switch - a single pole, double throw toggle switch located in the lower left-hand corner of the front panel. When in the "test" position, the timing circuitry generates a nominal 15 second delay time; when in "operate," the delay time is a minimum of 15 minutes in length.
3. Rate Switch - an eight position rotary switch located in the upper right-hand corner of the panel. This control allows the user to choose the delay time he desires in 15 minute increments from 15 to 120 minutes (2 hours). The numbers around the switch refer to the delay time in minutes.
4. Patient Pressure Switch - This control is a sensitive ribbon pressure switch which is placed under the patient to sense when a movement is made. It is attached to the package through a 4 pin connector located on the left side of the unit. When the user sits or lays on this switch, the contacts are closed. Whenever the patient moves, his action must be of sufficient magnitude to open the contacts in the pressure switch in order to actuate the alarm disable and/or reset circuitry.

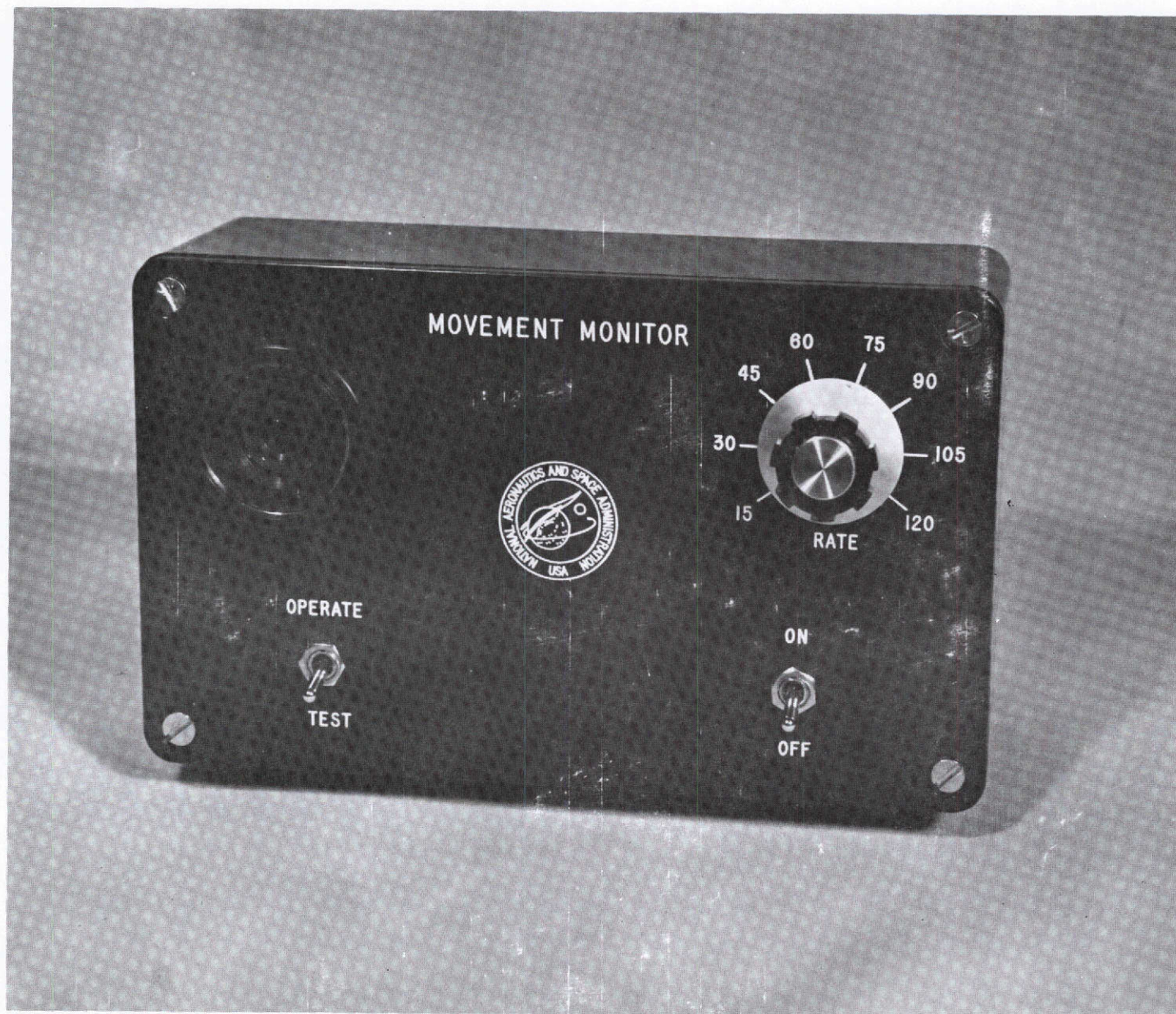


Figure 2 - FRONT PANEL



### Test Operation

A "test" mode of operation was included to provide a convenient method for checking the operation of the Movement Monitor. It is also suggested that this mode be used whenever explaining and demonstrating the device.

Operation in this mode is as follows:

1. Place the Test-Operate Switch in the "Test" position.
2. Place the Rate Switch in the "15" position.
3. Turn the Power Switch on. When this is done, a tone should be heard from the alarm buzzer.
4. Apply pressure to the Patient Pressure Switch. The alarm will be disabled and timing circuit reset.
5. Hold the Pressure Switch down. In approximately 15 seconds the alarm buzzer will sound. (The test circuit has not been precisely timed and may vary from 10 to 30 seconds, depending on the individual unit. The delay time will be consistent however, for any given unit.)
6. Release the Pressure Switch. The buzzer will continue sounding. Depress the switch and the device will be reset.
7. If the Pressure Switch is released before the timing sequence is completed, the alarm will sound. Depressing the switch will reset the circuit and deactivate the alarm.
8. If it is desired to check the operation of the Rate Switch, place the Rate Switch in the "30" position before depressing the pressure switch. In this position, the time before alarm should be twice as long as in the "15" position. The delay in the "45" position will be three times as long, the "60" position four times as long, and so on up to the "120" position which will be eight times as long as the delay in the "15" position of the Rate Switch.

### Normal Operation

Normal operation is identical to test operation except that the time delay is extended to a minimum of 15 minutes. Briefly, operation is as follows:

1. Place the Patient Pressure Switch beneath the patient.
2. Place the Rate Switch in the position which corresponds to the desired delay time.
3. Be sure the Test-Operate Switch is in the "Operate" position.
4. Turn the power on. If the Patient Pressure Switch is positioned properly, no alarm will be heard. If there is an alarm, check the position of the switch and the connector on the left side of the unit.
5. Have the patient lift or move himself. When he moves sufficiently to open the Pressure Switch, the alarm will sound. Placing pressure back on the switch will disable the alarm and reset the timing circuit.
6. The Movement Monitor is now in operation. Whenever the user makes a significant movement (one which causes the Pressure Switch to open) the alarm will sound. Returning pressure on the switch will disable the alarm and reset the timing circuit. If the patient does not move within the preselected time, the alarm will sound and movement will be required to reset the Movement Monitor.

### Maintenance

As mentioned earlier, the only maintenance normally required will be the periodic changing of the 9 volt transistor battery.

The battery is mounted inside the electronics package in a standard battery clip. To change the battery, remove the four (4) screws securing the front panel to the case, lift and fold the panel away from the case, disconnect the snap terminals from the battery, remove and install the new battery. Care should be taken when lifting the panel away from the case to avoid damage to the wire ribbons connecting the controls to the circuitry.



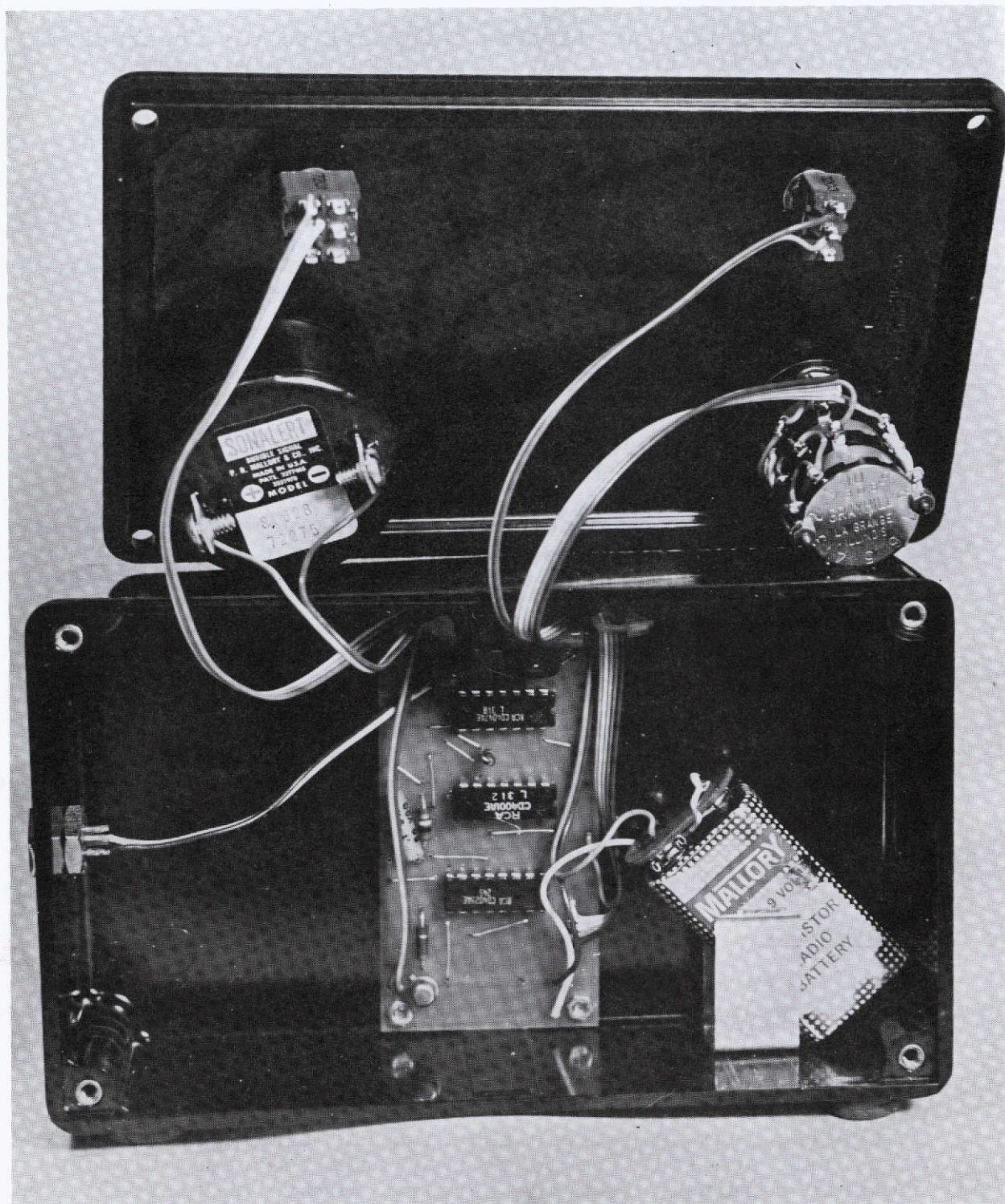


Figure 3 - INTERIOR VIEW

### III. TECHNICAL DISCUSSION

The Movement Monitor is primarily a digital logic device consisting of a timer, presetable binary counter, control/reset circuit, and an audible alarm. These sections are explained in detail in the following paragraphs. A functional block diagram is given in Figure 4.

#### Timer

The timing requirements for this device are not precise and are therefore met satisfactorily with a low frequency astable multivibrator. An RCA COS/MOS low-power astable multivibrator IC, CD4047, was used to generate the needed timing pulses. It was decided to use the COS/MOS circuitry in the Movement Monitor because of its high reliability, its ability to operate over a wide range of voltages with a minimum effect on operating characteristics, and its extremely low power requirements.

The frequency of the astable multivibrator is determined by the external components  $C_1$ ,  $C_2$ ,  $R_1$ , and  $R_2$ . (See Figure 5). These components were chosen to provide an oscillator cycle of 7.5 minutes. A 2:1 frequency divider is included in the CD4047 and was used to provide a clock output cycle of 15 minutes. In the test mode, the capacitors  $C_1$  and  $C_2$  are replaced by  $C_3$ , a 0.1 uf capacitor, to provide a clock output of approximately 15 seconds.

#### Presetable Binary Divider

This circuit allows the user to select the time delay period which is best suited to his particular needs. The CD 4029 is a presetable binary up/down counter connected in the count up mode. A preset binary number is entered into the counter through the jam inputs and clock pulses are then counted until a binary eight count is reached. The three section, 8 position, rotary "Rate" switch determines the binary preset entered into the register and therefore the number of 15 minute clock pulses counted to generate an output.

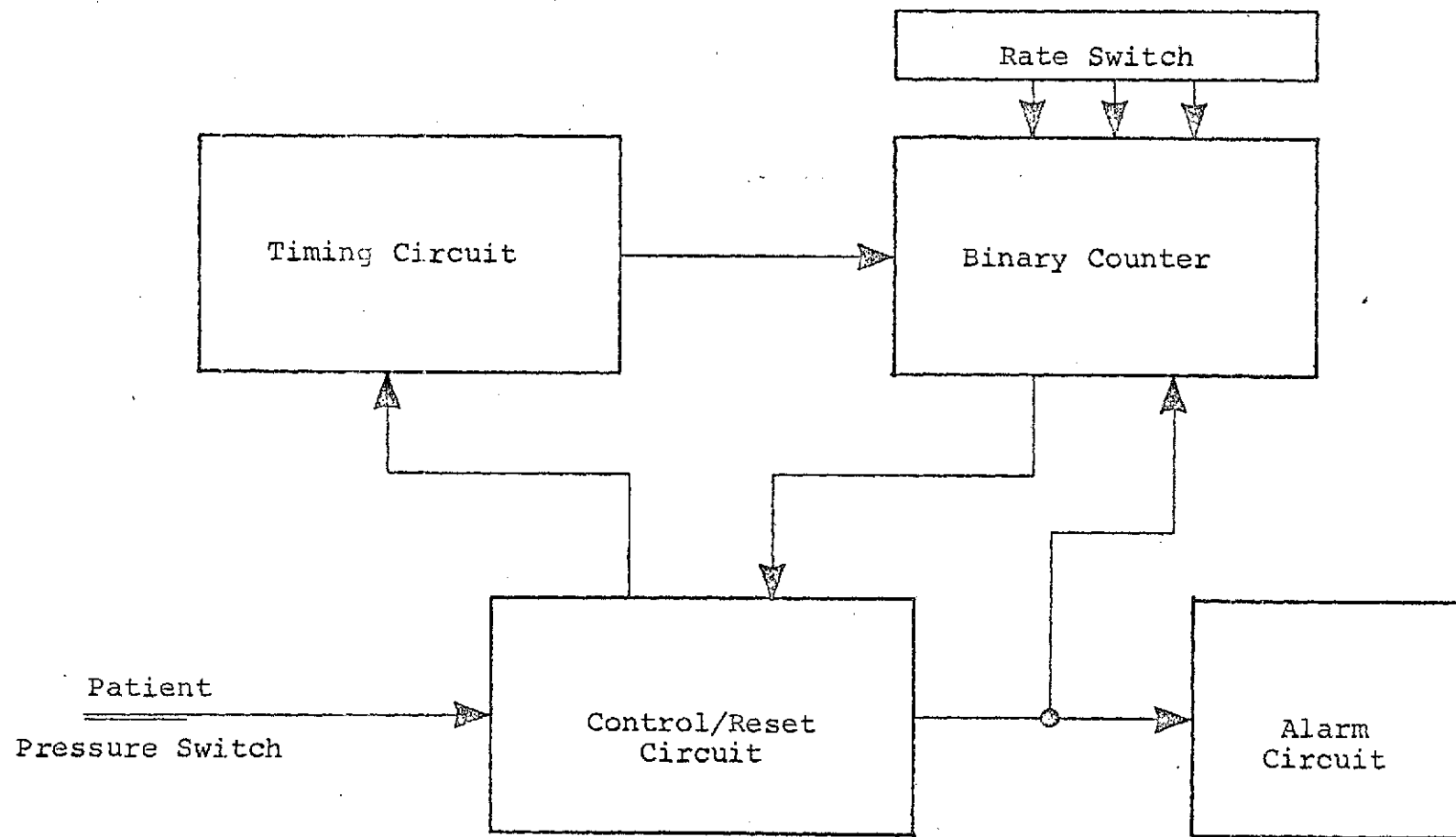


Figure 4 - BLOCK DIAGRAM

### Control/Reset Circuit

This circuit consists of the logic gates and associated components necessary to cause an alarm, and reset the timer and counter whenever the preset time has elapsed or the patient makes a significant movement.

Whenever an output is generated from the binary counter, the control gates inhibit further operation of both the oscillator and divider in the timing device. The clock input to the binary counter is also disabled and the alarm circuit activated. The circuit remains in this condition, with alarm sounding, until the user moves to first open, then reclose the contacts in the Patient Pressure Switch. This action resets the binary counter and removes the inhibit states applied to the timer, allowing a new period to begin. If the patient should move before the preset period has elapsed, the timer and binary counter are inhibited and the binary counter reset when the Patient Pressure Switch is opened; and a new period begun when the contacts are reclosed. The alarm will sound during the time the Patient Pressure Switch is open.

Three sections of a CD4001 quad 2 input NOR gate are used in the control/reset circuit.

### Alarm Circuit

The alarm circuit contains a Mallory "Sonalert" buzzer and a transistor driver. The buzzer is a low current, high intensity device which provides an output signal at approximately 2400 Hz. Output volume can be varied by changing the resistor  $R_5$  in the base of the transistor driver. Maximum volume is obtained when  $R_5$  is equal to 20K ohms.

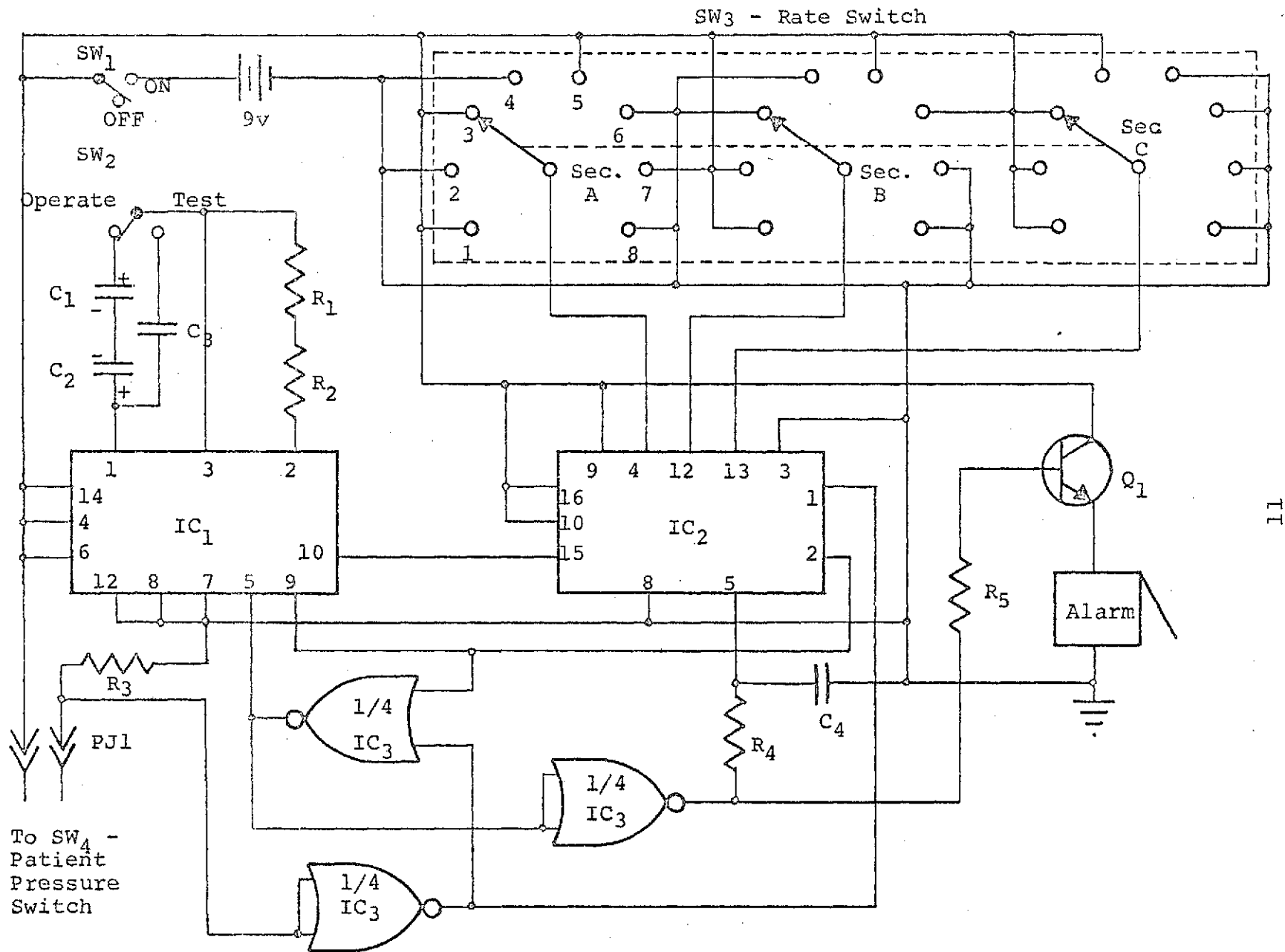


Figure 5 - SCHEMATIC DIAGRAM

#### IV. CONCLUSION

The Movement Monitor is a small, portable, inexpensive device which is designed to aid in the care and rehabilitation of paraplegic and brain damaged patients. In its intended use this device will provide the patient with a periodic reminder of the need to change body position to allow blood flow to those parts of the anatomy supporting the body weight. The periodic restoration of circulation will significantly decrease the possibilities of developing decubitus ulcers in these areas and therefore contribute much to the comfort and well-being of the patient.

While the Monitor was designed to meet a specific need, it is hoped that other uses can be found which will further aid in the care and rehabilitation of paraplegic, brain damaged and other handicapped persons.

## APPENDIX A

### Parts List and Construction Aids

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## MOVEMENT MONITOR

## Parts List

R <sub>1</sub>	10Meg., 5%, $\frac{1}{4}$ w., composition*
R <sub>2</sub>	8.1Meg., 5%, $\frac{1}{4}$ w., composition*
R <sub>3</sub> , R <sub>4</sub>	100K, 5%, $\frac{1}{4}$ w., composition
R <sub>5</sub>	1.5Meg., 5%, $\frac{1}{4}$ w., composition
C <sub>1</sub> , C <sub>2</sub>	22 uf, 15v, Kemet Type K22J15KS
C <sub>3</sub> , C <sub>4</sub>	0.1 uf, ceramic disc
Q <sub>1</sub>	NPN Transistor, silicon, 2H2222
IC <sub>1</sub>	COS/MOS CD4047AE Low-power astable multivibrator, RCA
IC <sub>2</sub>	COS/MOS CD4029AE, binary up/down counter, RCA
IC <sub>3</sub>	COS/MOS CD4001AE, quad 2-input Nor Gate, RCA
PJ <sub>1</sub>	Miniature 4-pin plug and receptacle, Type M4S-LRN, Winchester
SW <sub>1</sub> , SW <sub>2</sub>	Miniature toggle switch, SPDT, Type 8A1011, Micro
SW <sub>3</sub>	Rotary switch, 3 pole, 8 position, Type 5003-8, Grayhill
SW <sub>4</sub>	Ribbon switch, Type 107-LS controflex, Tapeswitch Corp.
Battery	9v transistor battery, Mallory Alkaline Duracell MN1604, or equiv.
Case	Instrument case, 6 $\frac{1}{2}$ x3-3/4x2, Type 240, Harry Davies Molding Co.
Cover	Instrument case cover, Type 241, Harry Davies Molding Co.

\*These values are approximate only. Actual values are determined to provide the desired oscillator output frequency (See Construction Aids).



## CONSTRUCTION SUGGESTIONS

While the design and construction of the Movement Monitor is relatively straightforward, there are three areas where further explanation may be of value to the builder.

### Timing Capacitors

Because the CD4047 astable multivibrator IC is an extremely high impedance device it is necessary that the timing capacitors have a very low leakage current. A nominal value of 10 uf is needed to develop the desired 7.5 minute per cycle oscillator frequency. A high quality, low leakage capacitor could probably be located which would function satisfactorily. However, it is felt that the present arrangement of  $C_1$  and  $C_2$  to form an essentially non-polarized 11 uf capacitor is preferable because of cost and space considerations. The exact value of the resulting capacitor is not critical as final timing is accomplished by adjusting the values of the timing resistors,  $R_1$  and  $R_2$ .

### Timing Procedure

The following procedure will assist the builder in selecting the correct value timing components in a minimum time and with the fewest number of component changes.

1. Connect the leads of a strip chart recorder or digital timer across the contacts on the alarm buzzer.
2. Place the Test-Operate Switch in "Operate," the Power Switch "ON," and close the contacts on the Patient Pressure Switch. The Rate Switch should be in the "15" position.
3. Allow the Movement Monitor to operate until the alarm sounds. Note the time from start-up to alarm. This time is labeled  $t_a$ .
4. Using  $t_a$ , and the nominal values for  $R_1$ ,  $R_2$  and  $C_1$ ,  $C_2$ , calculate  $k$ , using the following formula:

$$k = \frac{RC}{t_a}$$

With the values for  $R_T$  and  $C_T$  being 18.2 Megaohms and 11 uf respectively, the formula becomes:

$$k = \frac{(18.2)(11)}{t_a}$$

5. With the determined  $k$ , calculate the desired  $R_T$  required to provide a time period,  $T_A$ , of 15 minutes (900 seconds):

$$R_T = \frac{T_A}{KC}$$

or, using a nominal  $C$  value of 11 uf:

$$R_T = \frac{900}{(k)(11 \times 10^{-6})}$$

6. Adjust  $R_1$  and  $R_2$  to provide the  $R_T$  determined in step 5. Re-time the circuit to determine the new oscillator period. While the result may not be exact, because of component tolerances, it should be accurate enough for the needs of this device. A time of 15 minutes  $\pm$  15 seconds should be sufficient.

If it is felt that greater precision is desired, steps 4, 5 and 6 may be repeated. Knowing the exact value of  $C_T$  would also aid in precise timing.

#### Alarm Volume

The volume of the alarm buzzer has been set at a level which should alert the user without being annoyingly loud. If it is found that this level is not satisfactory it may be adjusted by changing the value of  $R_5$  in the base circuit of the transistor driver. Increasing  $R_5$  will decrease volume; decreasing  $R_5$  will increase the output level. Minimum allowable value for  $R_5$  is 20K ohms, smaller values may cause damage to the COS/MOS gates in the control circuitry.

If there are any questions on the use or construction of the Movement Monitor, please contact the NASA Biomedical Applications Team, Department of Bioengineering, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78284. (512) 684-5111.

## TECHNOLOGY APPLICATION REPORT

Problem: GLM-44 QUICKLY ADJUSTABLE CRUTCH

Institution: University of Texas Medical Branch  
Galveston, Texas 77550

Investigator: Dorothea Everett,  
Chief Physical Therapist

Acquisition Date: August, 1972 Completion Date: April, 1973

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### PROBLEM OBJECTIVE

A replacement was needed for the screws and wing nuts commonly used for adjusting crutches.

### BACKGROUND

Many patients at rehabilitation facilities need to be fitted for crutches or walkers at their first visit. Though it appears to be a minor activity in rehabilitation, it has been demonstrated that as much as 3-4 manhours of a therapist's time daily can be absorbed on this one simple operation because standard appliances are commonly assembled with screws and wing nuts which require considerable manipulation for adjustments.

### RESOLUTION

Since cost impact was given a high priority in resolving the problem, it was decided that a replacement for the screws and wing nuts would be preferable to a complete modification of existing crutch designs.

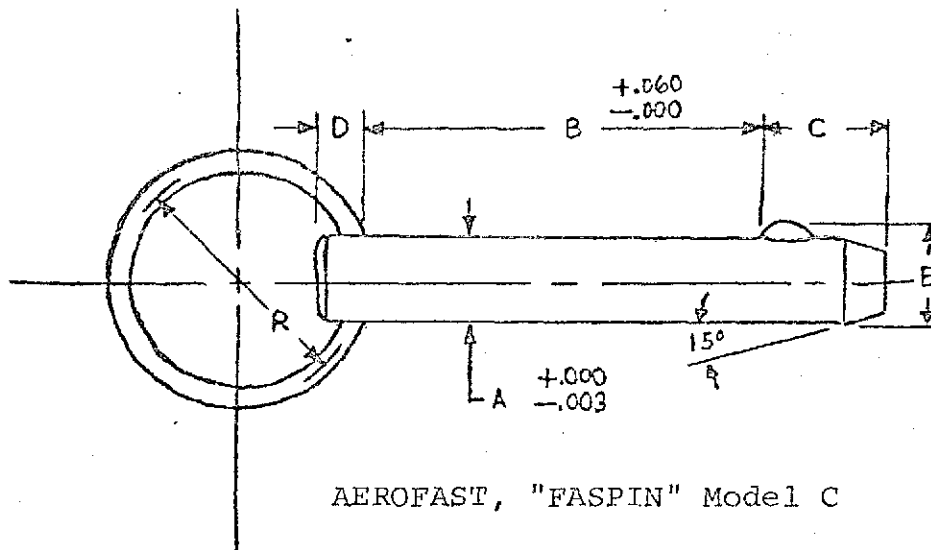
A pin-type fastener commonly used throughout the aerospace community was identified which would solve the problem. The pin is a ball-detent type having a fold-over lock ring. An illustration of the pin and source information follows this summary.

### EVALUATION

Use of the pins was demonstrated at the institution and was received with an enthusiastic response about its ease of use. The pins are inexpensive and allow use of standard crutches without modification. The investigator soon determined that these pins were so inexpensive that she started using the pins on the

crutches permanently, instead of just at fitting sessions.

#### HARDWARE INFORMATION:



Available from: Aerofast  
 P. O. Box 324  
 Wheaton, Illinois 60187

The following FASPIN types were used in this application:

C3-60R (used to replace screw and wing nut in crutch handle portion)

C3-20R (used to replace screw and wing nut in lower crutch portion for height adjustment)

Note: It would be desirable for further ease of manipulation that the ball detent be somewhat larger.

## TECHNOLOGY APPLICATION REPORT

Problem: GLM-46 ADJUSTABLE CRADLE TO COVER BURN PATIENTS

Institution: University of Texas Medical Branch  
Galveston, Texas 77550

Investigator: Dorothea Everett  
Chief Physical Therapist

Acquisition Date: August, 1972 Completion Date: April, 1973

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### PROBLEM OBJECTIVE

A stretcher cradle was needed for use during transportation of burn patients to and from treatment rooms.

### BACKGROUND

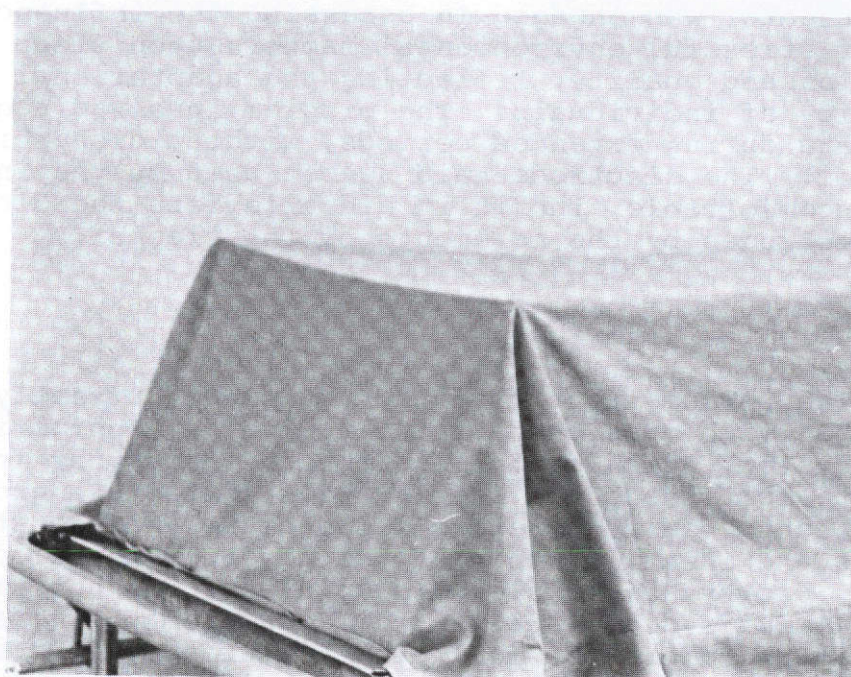
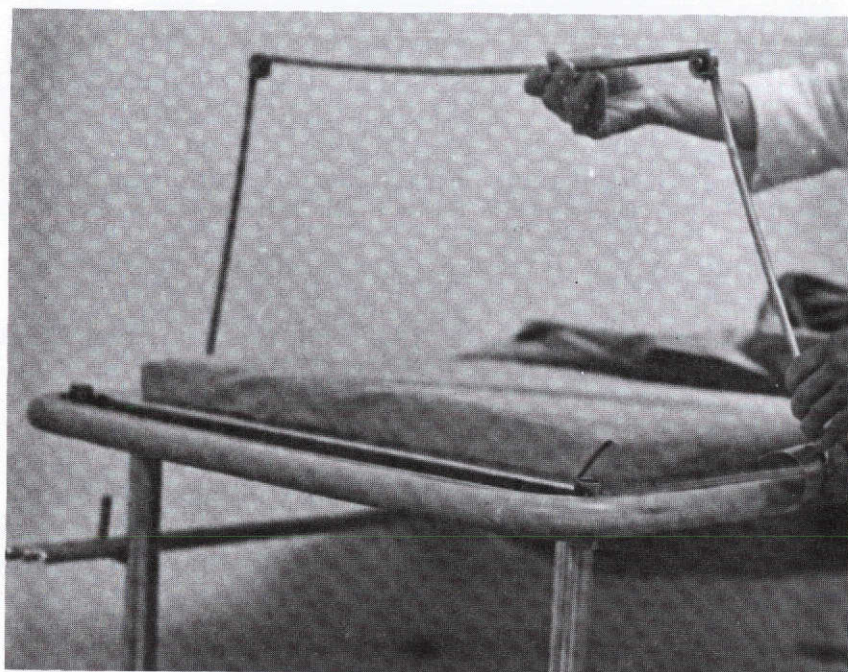
Burn patients are highly susceptible to infection through the skin. During transportation to and from treatment wards, the patient is enclosed in a canopy of sheets that covers his stretcher, supported by a cradle. The present cradle, although collapsible for easy storage, required two people for installation on the stretcher and would not accomodate variations--such as for an extremely large patient, traction devices, or splints. There was then the need for adjustment of the volume enclosed by the cradle.

### RESOLUTION

The BA Team identified a litter cradle developed by the School of Aerospace Medicine at Brooks Air Force Base in San Antonio for their mobile field hospital units. A copy of the cradle was demonstrated to the investigator at her facility and loan of the equipment for evaluation was granted. A sketch of the cradle configuration follows this summary.

### EVALUATION

The test cradle was delivered to the investigator in April, 1973. Since that time she has found that the device is quite simple, easy to manipulate, and may be used in varying sizes as needed.



GLM-46 Adjustable Cradle for Burn Patients

## TECHNOLOGY APPLICATION REPORT

Problem: OVA-4 ASSESSING SLEEP PSYCHOPHYSIOLOGY  
IN EXTREME ENVIRONMENTS

Institution: Veterans Administration Hospital  
Oklahoms City, Oklahoma

Investigator: Jay T. Shurley, M.D.

Acquisition Date: December, 1970 Completion Date: May, 1973

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### PROBLEM OBJECTIVE

The investigator needed a system for the assessment of the psychophysiology of sleep in extreme environments.

### BACKGROUND

Extreme, exotic, and stressful environmental conditions are encountered at Admundsen-Scott Station, Antartica. The investigator was engaged in assessing the influence of a unique set of stressful environmental factors upon sleep patterns, duration and quality, reflecting the adaptational methods and capacity of individuals. The program involved acquisition of EEG data during extended periods, without disturbing the sleeper. The electrode hard helmet used by the investigator was uncomfortable, though it did alleviate the disconnection of electrodes by the movements of the sleeper.

### RESOLUTION

The BATEam identified the equipment currently being used in the Skylab missions for the M133 Sleep Monitoring Experiment. This system, which contains electronic analyzer instrument and a soft electrode cap. The analyzer contains a group of six lamps connected to a series of discrete voltage steps which allows the identification of the level of consciousness: awake, drowsy, light sleep, deep sleep, and abnormally slow (coma). This sleep analyzer differs from previous instruments in that it offers the following features: (1) small size, (2) design for specifically determining the state of sleep, (3) operation in real time, (4) utilization of one channel of EEG activity, and (5) lack of interference from occasional electrode or motion artifact.

The instrument uses selected aspects of the total EEG signal to continuously assess the subject's stage of sleep. This



assessment is expressed as a DC voltage output proportional to the sleep stage. With a sampling rate of three samples per minute, this system is comparable to human interpretation by EEG experts who consider a block of EEG signals as a whole, rather than each individual EEG wave.

#### APPLICABLE NASA TECHNOLOGY

Reference NASA Tech Brief B70-10110 follows this summary. The NASA developed system is commercially available and is marketed by SCI Electronics, Inc., 8330 Broadway, Houston, Texas 77017. A copy of the manufacturer's brochure is reproduced in Appendix B of this report. Though the Technical Support Package for this device is not included here, it can be obtained utilizing the information contained in the NASA Tech Brief.

#### EVALUATION

Because of the nature of the investigator's requirements, just supplying him with the commercial information on the sleep analyzer was not enough. Extensive contacts and instructions were most cooperatively provided by Dr. Robert Frost, original NASA developer of the system, in conjunction with the BATeam coordination efforts. There were problems with new soft-cap requirements for which Dr. Frost supplied the investigator with an updated model for his work, and helped with some preamplifier problems. However, the investigator has stated that the help, equipment, and extensive information that has been provided under the BATeam program has been extremely useful. It assured him that this particular system had very important application in the work he was pursuing. At present he is engaged in plans to perform significant laboratory and field testing of the device.



# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Electronic Sleep Analyzer

An electronic analyzer instrument (schematic overleaf) has been designed and constructed in prototype form to automatically monitor the stages of sleep of a human subject. The analyzer provides a series of discrete voltage steps with each step corresponding to a clinical assessment of level of consciousness: awake, drowsy, light sleep, deep sleep, and abnormally slow (e.g., coma). The sleep level is also indicated by the illumination of one of six panel lamps. The instrument is based on the operation of an EEG (electroencephalogram), as the latter is generally recognized to be the most dependable indicator of the occurrence of sleep and of the various stages of sleep. The new instrument has been designed for possible use in manned spaceflight monitoring and would therefore have to be independent of human experts for proper interpretation of the data over extended time periods. In addition, for such use, it must operate over a limited telemetry bandwidth to allow continuous transmission of conventional EEG activity. This analyzer differs from previous sleep analyzers in that it includes all of the following features: (1) packageable in small size (for use on a spacecraft); (2) requires very little telemetry bandwidth or time; (3) designed specifically for the determination of state of sleep, (4) operational in real time, (5) requires only one channel of EEG activity (central to occipital); and (6) not excessively biased by occasional electrode or movement artifacts.

The instrument uses selected aspects of the total available EEG signal to continuously assess the sub-

ject's state of consciousness or sleep; this assessment is expressed as a dc output voltage proportional to sleep stage. It considers approximately 15 sec of EEG before making a decision concerning the level of sleep, and therefore the output changes very slowly. Thus, the desired information can be telemetered using as few as 3 samples per minute (each sample could be a 3-bit number proportional to the output voltage of the analyzer). This method is comparable to that of human interpretation, in which a block of EEG signals several seconds in duration is ordinarily considered as a whole, rather than in a wave-by-wave analysis.

### Note:

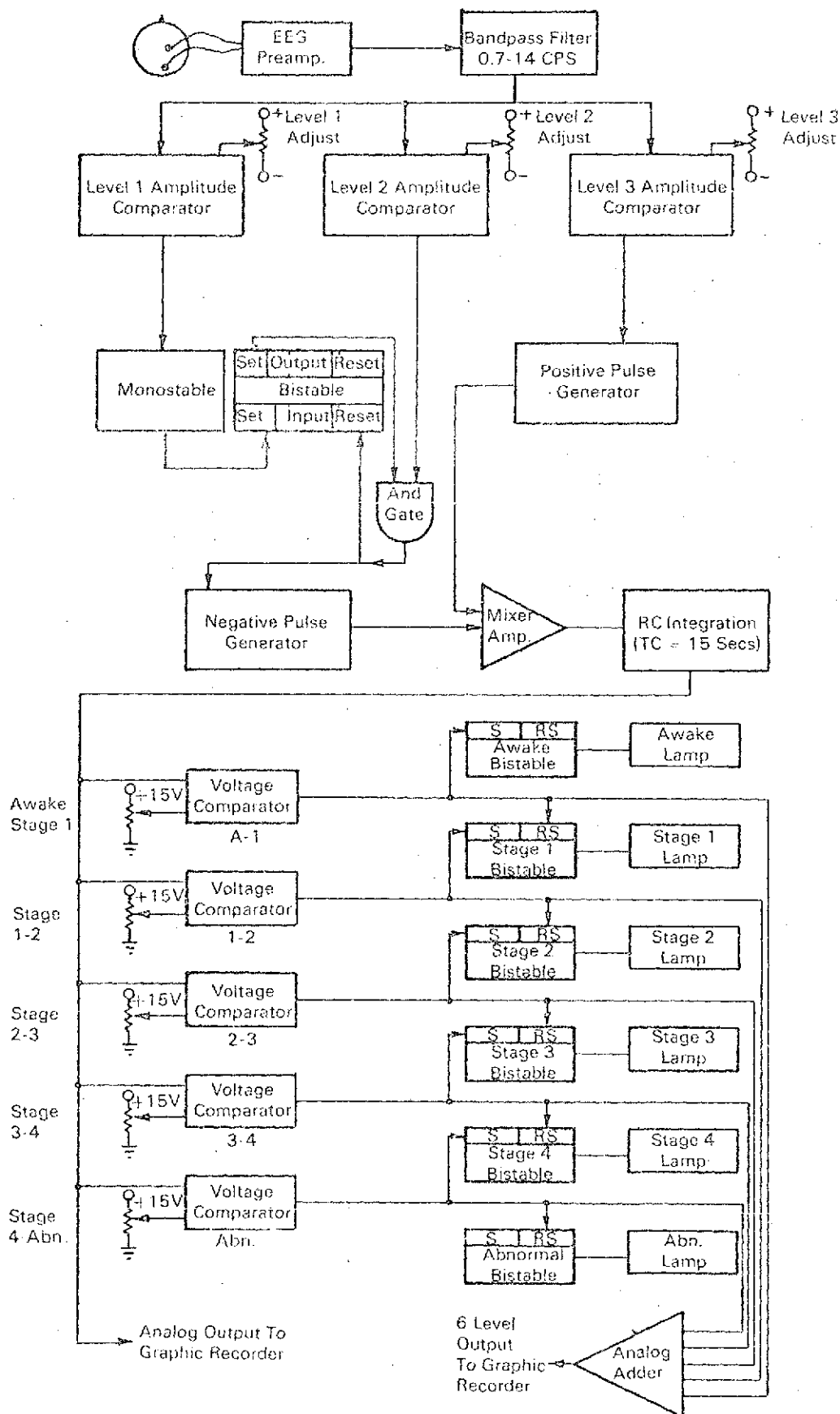
Requests for further information may be directed to:  
Technology Utilization Officer  
Manned Spacecraft Center, Code BM7  
Houston, Texas 77058  
Reference: TSP70-10110

### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. D. Frost, Jr., M.D. of  
Baylor University College of Medicine and  
The Methodist Hospital  
Houston, Texas  
under NASA grant  
(MSC-13282)

(continued overleaf)



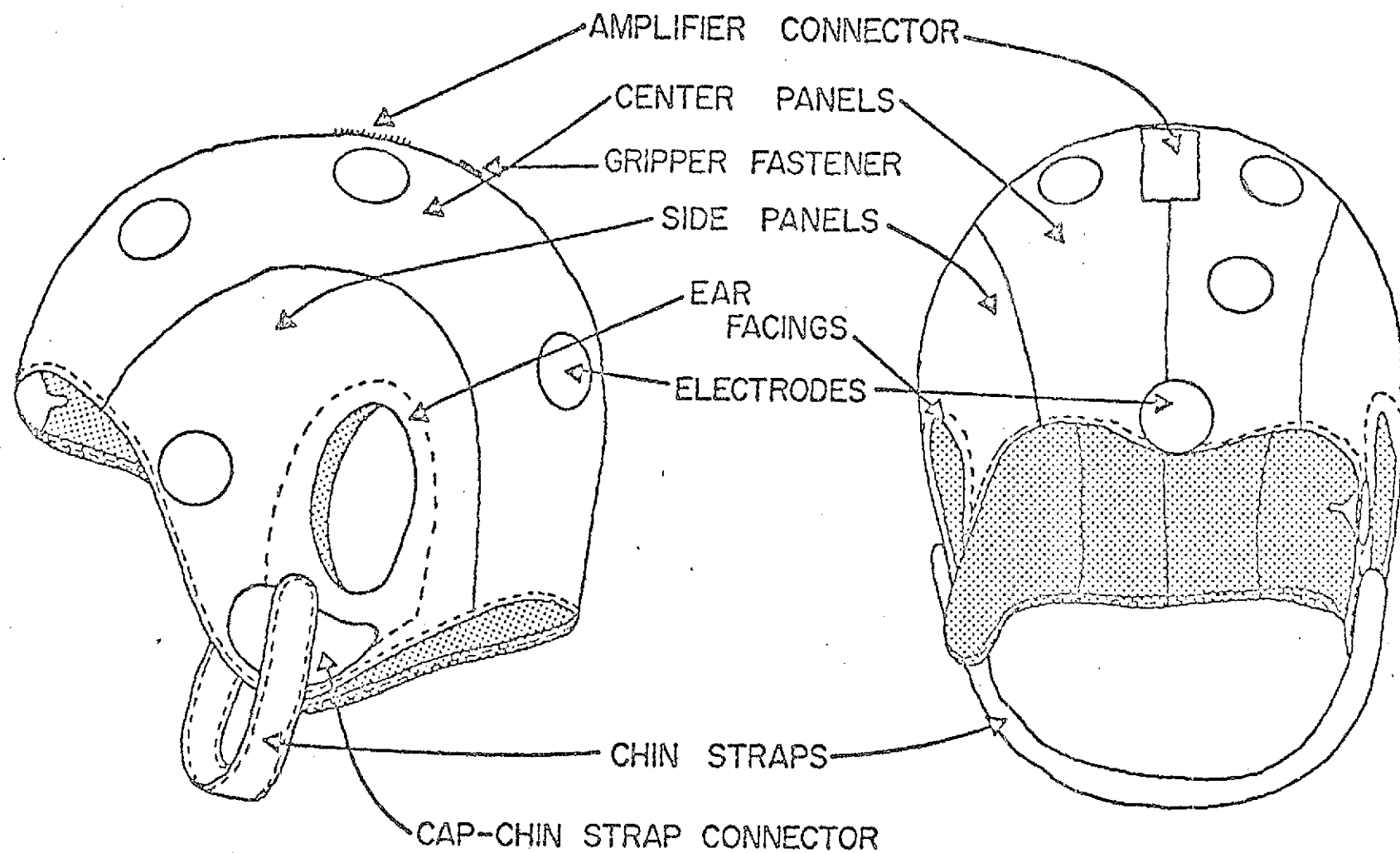


FIG. 7  
CAP CONSTRUCTION  
(OVA-4 Soft-Cap Configuration)

# NASA TECH BRIEF



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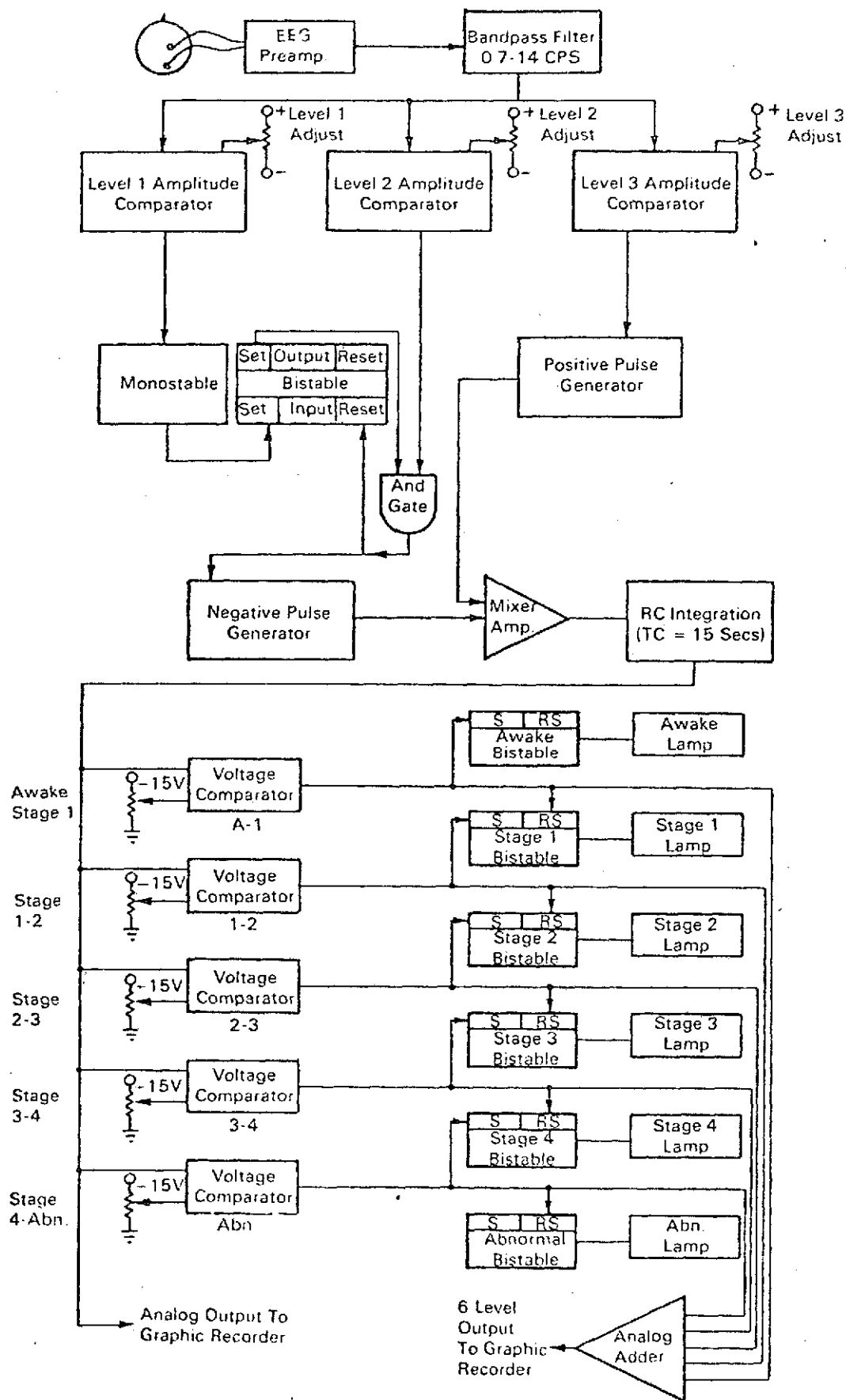
Requests for further information may be directed to:  
Technology Utilization Officer  
Manned Spacecraft Center, Code BM7  
Houston, Texas 77058  
Reference: TSP70-10110

### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. D. Frost, Jr., M.D. of  
Baylor University College of Medicine and  
The Methodist Hospital  
Houston, Texas  
under NASA grant  
(MSC-13282)

Continued overleaf



TECHNOLOGY APPLICATION REPORT

Problem: RRC-8 ULTRA-THIN ELECTROMYOGRAPHIC NEEDLES  
Institution: Rosewood General Hospital  
Houston, Texas  
Investigator: Robert D. Sine, M.D.  
Acquisition Date: January, 1971 Completion Date: June, 1973

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## PROBLEM OBJECTIVE

A biocompatible electrical conductor alloy was needed for the fabrication of electromyographic needles smaller than is currently possible with stainless steel.

## BACKGROUND

Excessive pain is generated in the skin of patients by the repeated skin punctures of an electromyographic examination. During these examinations a needle electrode is inserted through the skin and into the muscles of the arms, legs, and back for the evaluation of nerve and muscle damage. The associated pain appears to be closely related to the diameter of the electrode. Currently available electromyographic (EMG) electrodes fabricated from stainless steel can only be made as small as .016 inch. Needles made below this diameter are extremely subject to bending at the shaft (warping) and point (fish-hooking). Non-invasive techniques for EMG recording have undergone significant improvement recently, but the investigator desired to remain with the accuracy provided by the invasive means.

## RESOLUTION

An electrical conducting alloy was identified through Langley Research Center, where it was being used for thermocouples. This alloy, composed of 60% iridium and 40% rhodium, exhibited sufficiently superior physical properties to allow the fabrication of needles from .010 inch diameter wire, as compared to the .016 inch diameter wire required with stainless steel. Langley also suggested tungsten wire of .009 inch as an alternative, in the event the iridium-rhodium needles were not cost-effective.

Dr. Harvey Herring at Langley Research Center furnished a small quantity of the .010 iridium-rhodium wire to Robert Lawrence, Ohio State University, who completed the fabrication of the electrodes by teflon coating and insulating the needles and attaching the electrical connectors.

#### EVALUATION

To quote the investigator's evaluation report, "There is no question but that the decreased width seems to make a difference in the pain in that there was an increased tolerance for muscle exploration along with decreased anxiety, which yielded better testing all around."

The smaller diameter wire also was beneficial in another area. Although the needles did flex as they initially contacted the skin, they penetrated with more ease than the standard needle. The strength of the needles was also demonstrated in one examination in which "the subject very strongly contracted the muscles of his back. As there are a number of layers of muscles in the back, each one produced its own curve and (resulted in) a double S-shaped, curved needle." The needle did not break, so efficient and safe removal was accomplished. The investigator has expressed enthusiastic overall response and has stated a further need for a number of these .010 needles for extensive use.

TECA, a supplier of electromyographic equipment, is currently considering the production and marketing of the new iridium-rhodium needles.

## TECHNOLOGY APPLICATION REPORT

Problem: SNM-26 MONITORING OF PELVIC PRESSURE OF  
WOMEN IN LABOR

Institution: University of Texas Medical School  
San Antonio, Texas

Investigator: Marvin L. Chatkoff, M.D.  
Department of Obstetrics-Gynecology

Acquisition Date: June, 1972 Completion Date: January, 1973

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### PROBLEM OBJECTIVE

The investigator needed a rugged, cost-effective completely portable monitoring and recording system capable of recording and monitoring pelvic pressure in pregnant women.

### BACKGROUND

For large scale studies being performed on site among Rhodesian tribes where social and religious customs require completely natural childbirth and do not allow for recognized medical techniques for complications, especially for Cæsarian section, the investigators wanted a device to help them evaluate physiological conditions, especially pelvic pressure during labor and birth. The device should be completely portable and be capable of measuring DC levels indicative of the pressure parameter.

### RESOLUTION

It was determined that other NASA-BATeam, developed technology (previously used for GLM-32) would be applicable for this solution. The technology incorporates three NASA Tech Briefs:

1. B64-10171 "Subminiature Biotelemetry Unit Permits Physiological Investigations."
2. B67-10357 "Digital-to-Analog Converter Operates from Low Level Inputs,"
3. B71-10276 "A Real-Time Statistical Time-Series Analyzer."



B64-10171 provided a modulator for placing the pressure data on tape; B67-10357 was modified by the BATEam to produce single source detection rather than triple; and B71-10276 provided a system which obtained low frequency information from digital data. The system allows data storage on cassettes in an inexpensive home-type tape recorder. This allows portable use in the remote test areas of Rhodesia.

### Operational Discussion of the Pressure Recording Unit

MODULATOR (schematic follows summary) - The sub-carrier oscillator is a voltage controlled pulse rate oscillator. The input voltage from the pressure transducer is the modulating signal. This changing voltage determines the deviation from the static (center) frequency. Potentiometer (250K) is used to adjust the center frequency to the desired value. The input capacitor is large to allow low frequency changes to be coupled into the oscillator. At the output of the oscillator a capacitor and resistor network were added to provide wave-shaping for acceptable recordings on the cassette tape recorder.

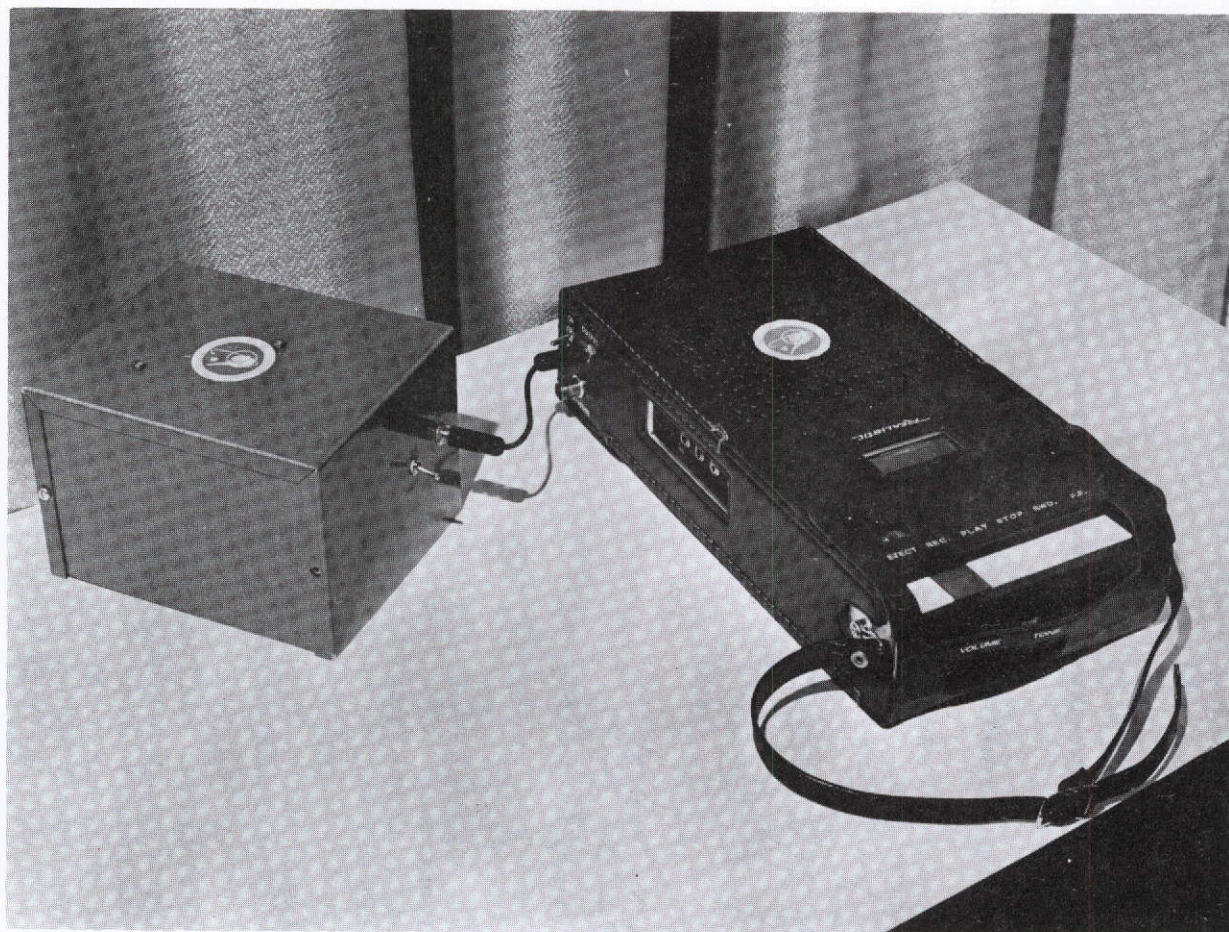
Care needs to be taken when setting the center frequency because too large an input signal will cause the pulse rate oscillator to cease oscillation. Adjustment of the bias level of the input transistor can provide some latitude in correcting this problem, depending on the incoming wave shape.

DEMODULATOR (schematic follows summary) - The demodulator consists of a one-shot multivibrator whose fixed duration output pulse is integrated to recover the modulating signal. The one-shot multivibrator is preceeded by a differentiator and a zero crossing detector and provides a sharp transition in the output for all zero crossings of the input signal. This circuit takes the nearly triangular waves at the input and squares them. Once these square waves are obtained, they are applied to the differentiator to produce triggers for the one-shot multivibrator. Negative triggers into the one-shot will cause positive pulses of fixed duration, out to the integrator. The integration will smooth these pulses to reproduce the original modulating signal.

The values of capacitor and resistor in both the integrator and the differentiator are determined by the center frequency and the amount of deviation produced in recording the data. The values are best determined empirically as the type and quality of the tape recorder used will determine the exact wave shape.

### EVALUATION

Initial use in the investigator's research settings show the device operational and feasible. Field-testing of the device will follow pending their project arrangements.



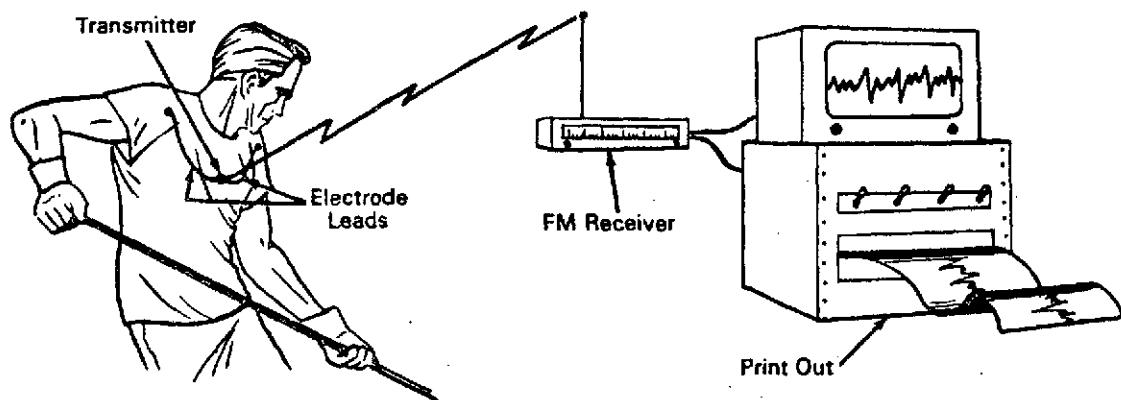
SNM-26 Instrument for Monitoring Pelvic Pressure of Women During Labor

# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Subminiature Biotelemetry Unit Permits Remote Physiological Investigations



**The problem:** The measurement of biopotential response in humans or animals to controlled environmental stimuli has traditionally been impaired by encumbering electrical leads or bulky amplifying and transmitting equipment.

**The solution:** A subminiature, high-performance, biopotential telemetry transmitter operating in the standard 88- to 108-megacycle FM band.

**How it's done:** The transmitter was designed using standard, inexpensive, commercially available components and assembly techniques which permit easy and repeatable assembly with no sacrifice of performance or reliability. The transmitter is 0.74 inch in diameter by 0.20-inch thick and weighs two grams. A mercury cell provides power for operation in two modes, selected by the interchange of three components in the basic circuit. In one mode the transmitter has a two-day operating life with a 100-foot range; in the other, the transmitter has a 48-day operating life with a 10-foot range. Conventional biomedical electrodes are used to connect the transmitter to the subject.

### Notes:

1. In tests, humans have worn the unit for four or five days without discomfort and have generated useful data while engaged in normal activities.
2. Further information concerning this innovation is described in NASA-TM-X-54068, "A Miniature Biopotential Telemetry System" by Gordon J. Deboo and Thomas B. Fryer, May 1964.
3. A related innovation is described in NASA Tech Brief 64-10025, May 1964.
4. Inquiries may also be directed to:

Technology Utilization Officer  
Ames Research Center  
Moffett Field, California, 94035  
Reference: B64-10171

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

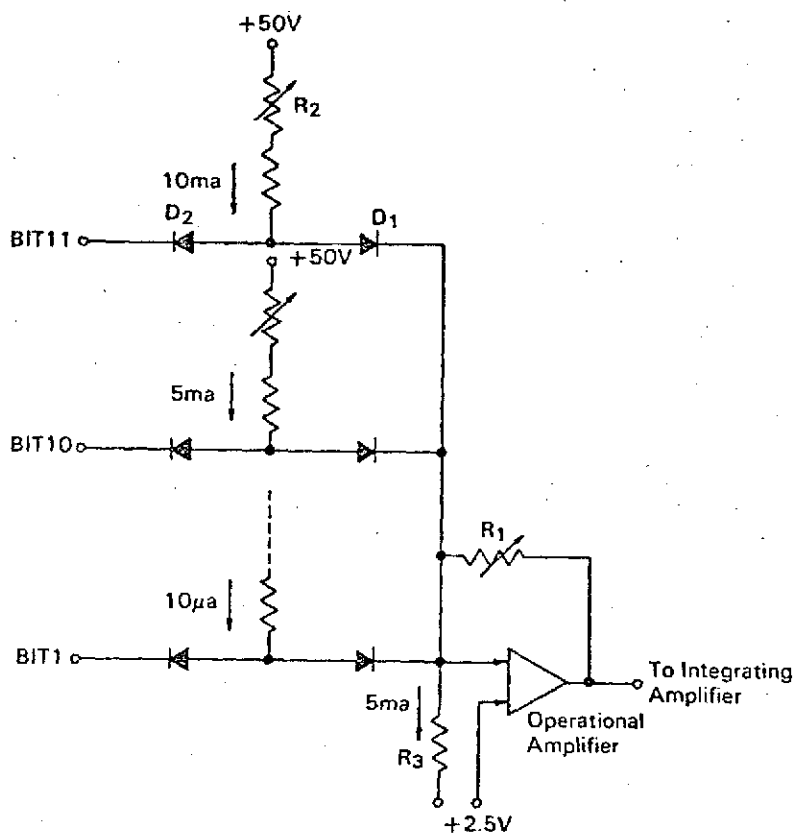
Source: Ames Research Center (ARC-39)

# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Digital-to-Analog Converter Operates from Low Level Inputs



### The problem:

To control a voltage controlled oscillator from computer output binary data representing a rate at which the oscillator is to change. The computer derived rate number is held in a buffer that is periodically read out into a digital-to-analog (D/A) converter. The buffer register uses integrated circuits not capable of driving conventional D/A converter circuits without prior amplification.

### The solution:

A circuit that operates with low level output devices such as integrated circuit registers and devices with somewhat variable output levels. Normal transition level is +2.5v so that if the flip-flop register output voltage at any binary order position is less positive than +2.5v, the "zero" state exists at the input to the D/A converter; if the register output voltage is more positive than +2.5v, the "one" state exists.

(continued overleaf)

**How it's done:**

A standard reference power supply of 50v is used for the reference source. By means of selected resistors in the input branches, the current in each succeeding branch from bit 1 to bit 11 is doubled as an initial calibration of the current input to the operational amplifier.

As the illustration shows, the converter contains multiple binary scaled current sources (bits 1 through 11) that are summed by the operational amplifier. Each of these sources has two steering diodes,  $D_1$  and  $D_2$ . Diode  $D_1$  directs current flow to the operational amplifier and  $D_2$  directs current flow to the driving circuit. If the input voltage is less positive than +2.5v, current is steered by  $D_2$  away from the operational amplifier and into the driving circuit. If the input voltage is more positive than +2.5v,  $D_2$  is back biased and  $D_1$  steers the current into the operational amplifier where its binary value contributes to the output dc voltage. Amplifier gain is adjusted by  $R_1$  from +5v to -5v over the complete range of code inputs. Bias is set for a constant +2.5v at the amplifier input by external means. The D/A converter is calibrated by adjusting  $R_2$  in each branch for monotonic operation.

A major portion of drift and voltage uncertainty versus temperature variation is due to the variable voltage drop across the steering diodes leading to the operational amplifier. For example, in the most significant bit position, a 50 mv change is equivalent to

one whole code increment change. This effect diminishes by a factor of two for each successive lower order bit position. To minimize this condition, the operational amplifier steering diodes in the four most significant bit positions (bits 8, 9, 10, and 11) are metal silicon hot carrier diodes with low barrier potential to minimize drift due to temperature variation. The voltage drop temperature coefficient of these diodes approaches zero for currents in the vicinity of 10 ma. At low currents the temperature coefficient is much less than that of the silicon junction diodes used in the other steering positions.

**Notes:**

1. The low level operational capability of this D/A converter makes it suitable for commercial computer and control applications involving integrated circuitry.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer  
Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, California 91103  
Reference: B67-10357

**Patent status:**

No patent action is contemplated by NASA.

Source: Robin A. Winkelstein  
(JPL-907)



# NASA TECH BRIEF

## Manned Spacecraft Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### A Real-Time Statistical Time-Series Analyzer

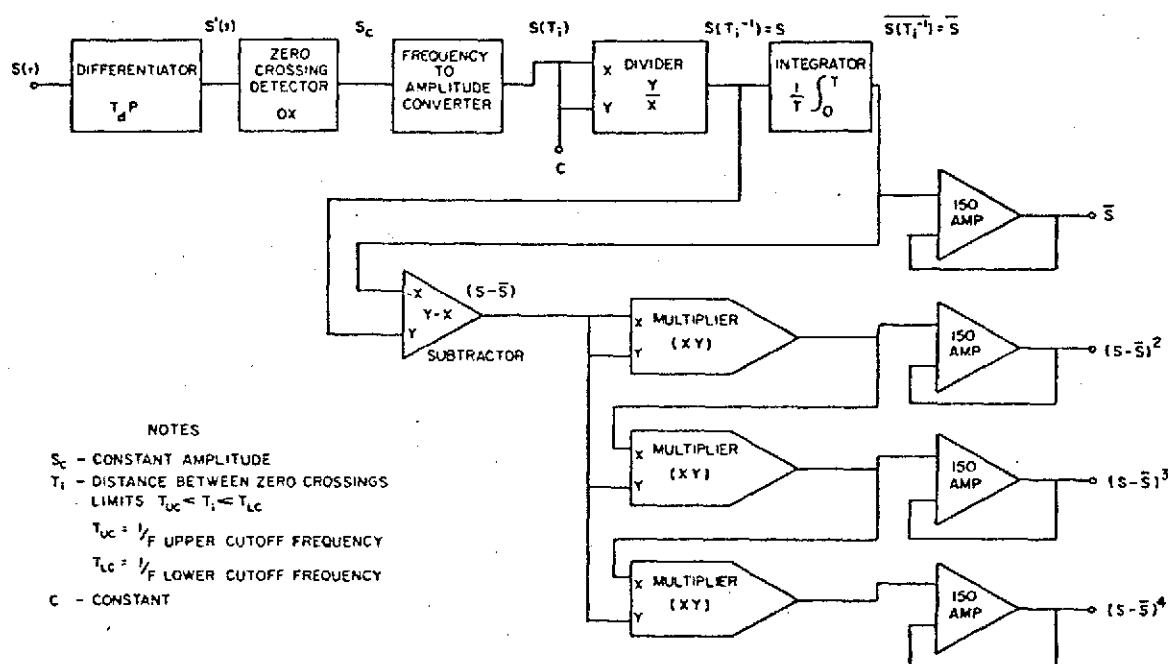


Figure 1. General Block Diagram of Real-Time Statistical Time-Series Analysis

A relatively inexpensive device operating on the electrical time representation of an input signal has been conceived. This device will extract the average frequency of human speech and produce the second, third and fourth moments of instantaneous frequency about this average. Because it can be used by personnel who have not had specialized training it has significant advantages which will appeal to government agencies and industries concerned with communications.

Attempts have been made to simulate the process

of a real-time statistical analysis of the time intervals between zero axis crossings of a given input signal in the past. But these have been confined to the laboratory and no self-contained system has been built specifically for this purpose. Because the laboratory test sets have been limited to a specialized purpose they have had no general application.

This innovation comprises four major components: a zero-crossing detector, a frequency-to-amplitude converter, an integrator, and a moment generating net-

(continued overleaf)

work. Figure 1 illustrates the function of the analysis operation. The input signal is first passed through the zero-crossing detector and the signal zero-crossing signal is then converted by the frequency-to-amplitude converter. From here the converted signal frequencies are passed through a network to allow the integrator to measure the average frequency. This is then subtracted from the instantaneous frequency and appropriately multiplied to produce the second, third and fourth statistical moments of the input signal zero-crossings in real-time.

In general the Analyzer can be used to perform statistical analysis on the zero-crossing of almost any signal. But its main purpose is to analyze human speech. The device does this by defining and displaying the first fourth central statistical moments of the reciprocal time distance between successive zero-crossings. The analysis begins by converting the input speech signal to a square wave showing variations only in the signal zero-crossing points. Then, the time intervals between the varying zero-crossing joints are measured, inverted, and converted with relative amplitudes. These amplitudes are averaged, and then used to calculate the second, third and fourth central statistical moments. When displayed on an oscilloscope these moments illustrate the emphasis of the transition between phonetic sounds in given speech samples.

The advantages of this innovation are that it can be operated by non-specialized personnel to provide speech analysis without the use of complex ancillary equipment such as computers. Moreover, the Statistical Time-Series Analyzer has a selectable bandwidth. As such it will be of interest to the communications industry where complex waveforms need to be analyzed.

#### **Note:**

Requests for further information may be directed to:

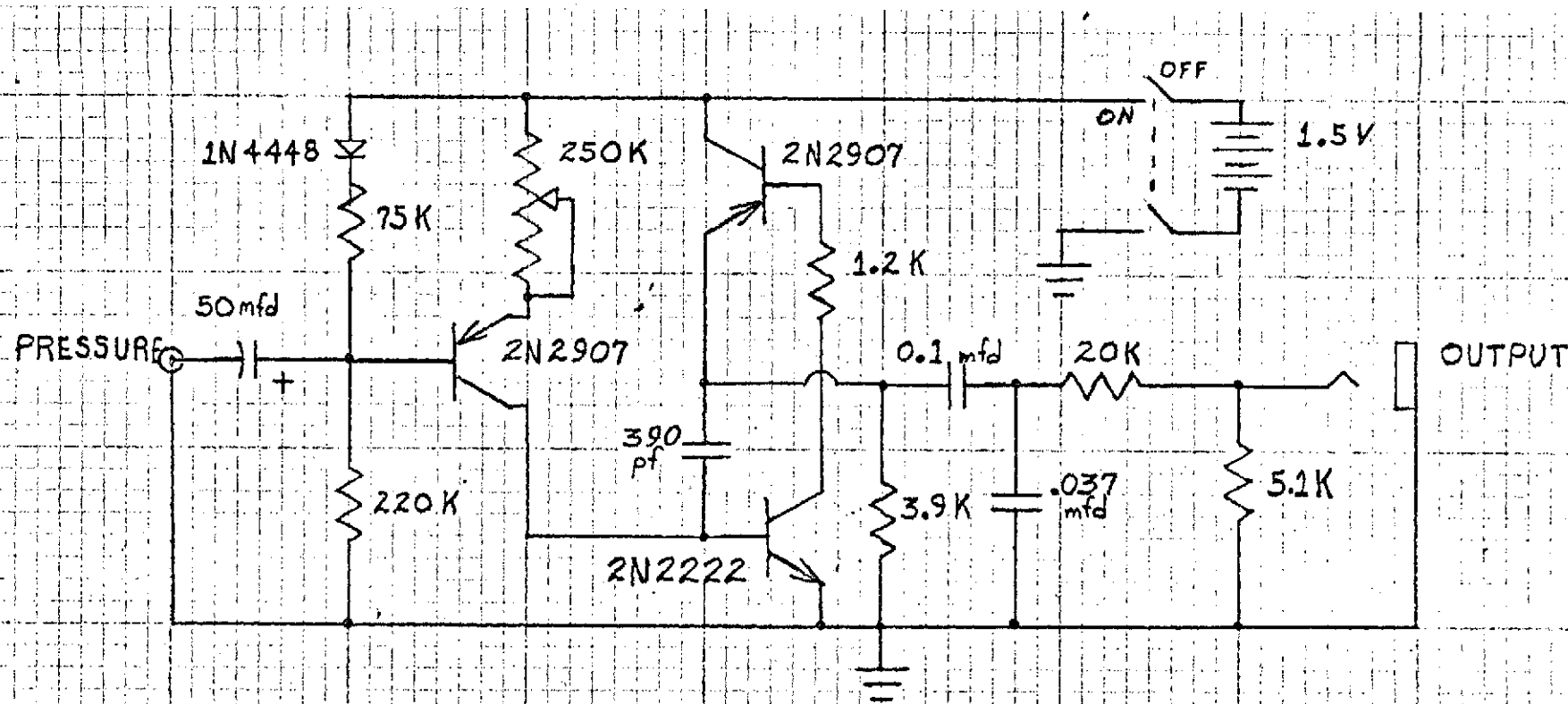
Technology Utilization Officer  
Manned Spacecraft Center, Code JM7  
Houston, Texas 77058  
Reference: TSP71-10276

#### **Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to:

Patent Counsel  
Mail Code AM  
NASA Manned Spacecraft Center  
Houston, Texas 77058

Source: Carrington H. Stewart  
Manned Spacecraft Center  
(MSC-12428)



# Notes:

1. .037mfd capacitor used to shape output for acceptable recording
2. SCO frequency set at 2.0KHz
3. Maximum input of 0.150 Volts will give oscillator deviation of  $\pm 400$  Hz

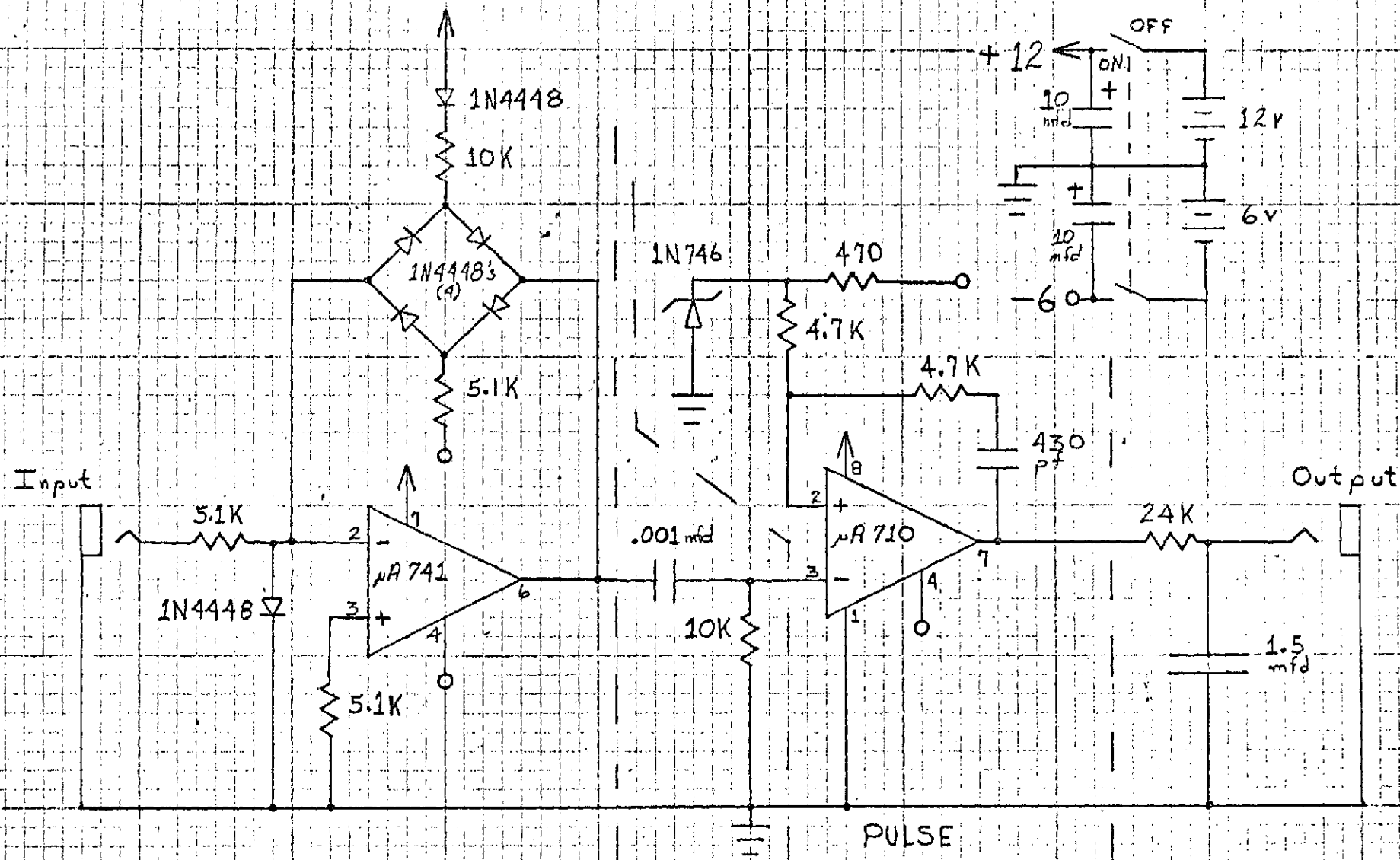
Subcarrier Oscillator

Modulator

SNM-26

August 31, 1972





ZERO CROSSING DETECTOR

DIFFERENTIATOR

PULSE  
COUNTING DEMODULATOR

INTEGRATOR

DEMOMULATOR  
SNM-26  
August 31, 1972

TECHNICAL SUPPORT PACKAGE FOR  
BIOPOTENTIAL MONITORING WITH INEXPENSIVE  
OFFICE-TYPE CASSETTE RECORDERS

NASA BIOMEDICAL APPLICATIONS TEAM  
SwRI INSTITUTE

Problems GLM-32 & SNM-26  
Problem BVA-1 (Telemetry Option)

September 27, 1972

## BIOPOTENTIAL MONITORING WITH INEXPENSIVE OFFICE-TYPE CASSETTE RECORDERS

### Abstract

Monitoring vital signs of hospital and ambulatory patients is becoming more necessary as new sophisticated medical treatment becomes available. Acquiring and analyzing this data from patients in intensive care units (ICU) and other medical environments has been reasonably routine and requires little additional equipment over and above that normally found in the hospital. Medical personnel, handling large numbers of cardiac outpatients through clinics, rehabilitation centers and home or office routines, need methods to acquire, store, and analyze the medical data. One method of achieving this is to place the data on magnetic tape. Medical grade recording systems exist to hard wire record biopotential signals, but they are so expensive that they price themselves outside most physicians' means. This paper describes a low cost system that will accept either hard wire or telemetered data and store it on an office-type cassette recorder. Replay features are also built into the recorder package and FM radio-recorder combinations are commercially available. Commercial medical units at present do not include the telemetry feature.

## Brief Technical Description of Biopotential Monitoring with Inexpensive Office-Type Cassette Recorder

This system has the ability to monitor ECG, CSR, EEG, temperature, and pressure and with proper signal conditioning either hard wire or telemeter the data to the cassette recorder. Once the information is stored on tape, the system also demodulates the digitized data for analog presentation. The entire system is fabricated into the carrying case of the recorders maintaining the portability feature.

NOTE: This paper describes only ECG and pressure features.

The system includes three subsystems:

1. Signal conditioner - modulator/transmitter
2. Cassette Recorder/FM receiver
3. Demodulator

The signal conditioner properly amplifies the ECG or the pressure signal and is pulse rate modulated at a center frequency best suited for the recorder utilized. Modulation is necessary because of the low frequency limitation of the recorder. If telemetry is desired, a transmitter is added to the signal conditioner and packaged for remote use.

Assembly 2 consists of an inexpensive cassette recorder. If the telemetry option is to be used, a combination FM radio-cassette recorder is utilized.

The demodulator accepts any pulse rate modulated signal placed on the tape. This type of demodulator is not locked to the modulator so is independent of modulating frequency and battery voltage fluctuations. Therefore, accurate time measurements are not assured. If accurate time measurements are desired, a phase locked loop demodulator is used.

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II. Operating Instructions	2
III. Technical Discussion	4
IV. Summary	10
APPENDIX      Waveshapes	11

## LIST OF FIGURES

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Figure 2.	System Schematic	6
Figure 3.	Biopotential Transmitter	8
Figure 4.	Demodulator (PLL)	9

## I. Introduction

The cassette recorder approach to medical monitoring was developed in response to many physicians' needs for a low cost, light weight, portable recording instrument. Cassette recorders in their original condition do not have a frequency response amenable with low frequency biomedical signals. Therefore, signal conditioning is required to raise these low frequency signals to a frequency band that provides the best fit to the cassette recorder utilized.

The design goals were to (1) develop low cost interface signal conditioners for low cost cassette recorders, (2) provide sufficient versatility in design to allow recording of a wide range of biomedical signals, and (3) fabricate the system in such a way as to maintain the portability of the entire package.

It was found that a wealth of NASA developed electronic circuits existed which could be incorporated to achieve all the design goals. Actually, many NASA developed circuits exist that could be incorporated into the system to further diversify the system on a modular basis.

## II. Operating Instructions

Hard wire recording of ECG, pressure, or other biopotential signals is accomplished by connecting electrodes or transducer leads into the input amplifier-modulator (See Figure 1). Setting the function switch to DIRECT prepares the recorder for use. The standard controls for operation of the recorder are then used to record.

Telemetry recording follows by applying electrodes or transducer to the patient and connecting them to the transmitter. Switch the function to RADIO which prepares the recorder for use with telemetry.

Voice recording is achieved by plugging in the microphone and turning the function switch to OFF. The off position returns the cassette recorder to its unmodified state.

Turning the function switch to REPLAY and utilizing the playback controls on the recorder engages the demodulator which changes the PRM signals into the original biopotential signals.

Each of the functions are independent of one another and few problems arise in operation. The electronics can be packaged into the accessory compartment of the recorder case.

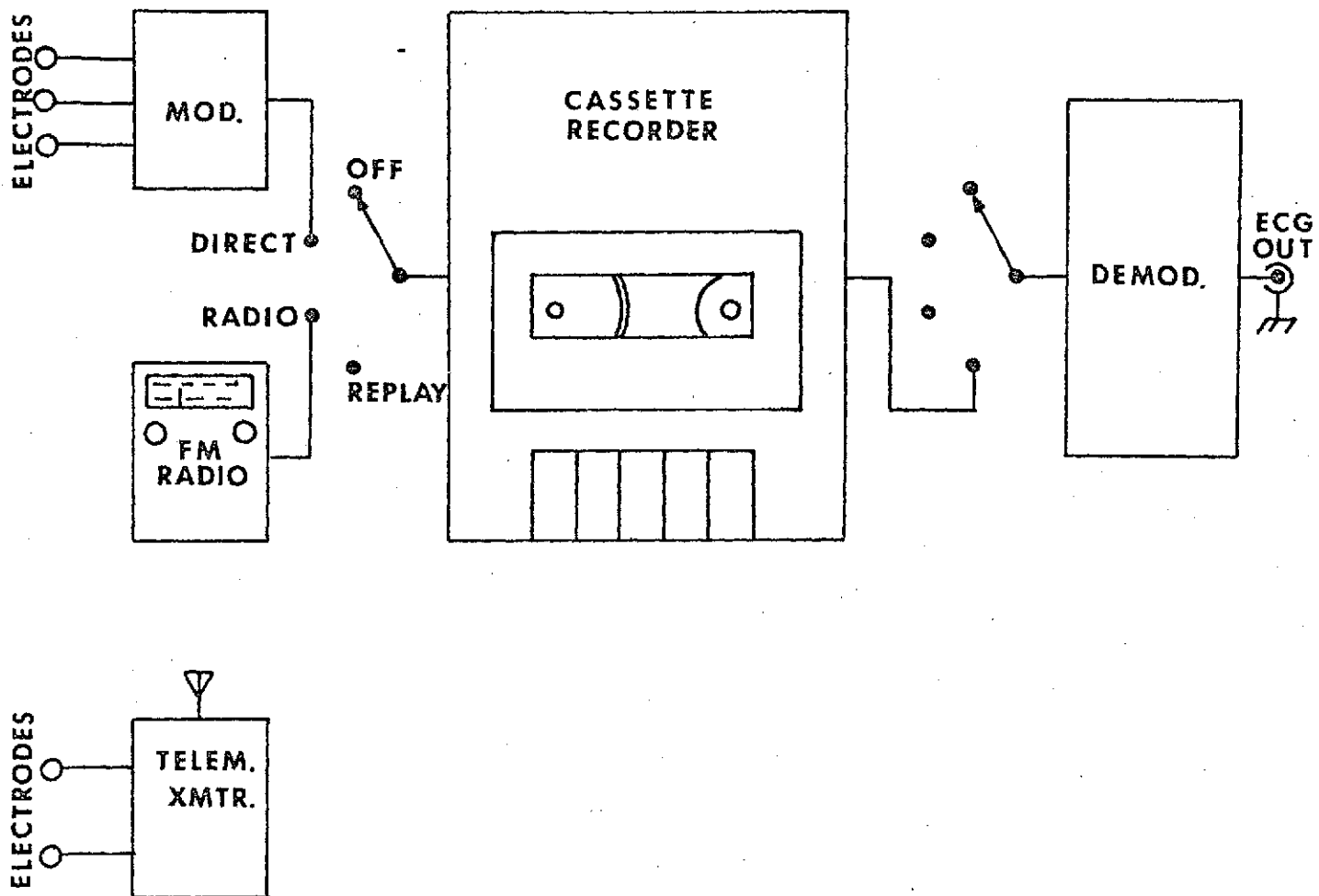


FIGURE 1. SYSTEM BLOCK DIAGRAM



### III. Technical Discussion

Office type cassette recorders costing under \$100 offer automatic level control, multiplicity of inputs, AM-FM radio, light weight and battery operation, all desirable for portable recording.

The frequency response of these recorders at 1-7/8 ips tape speed normally lies between 60Hz - 10 kHz. Much useful biomedical data lies between DC and 100 Hz. For the recorder to handle this information, it is necessary to condition this information at a frequency amenable to the recorder, preferably the mid-range response.

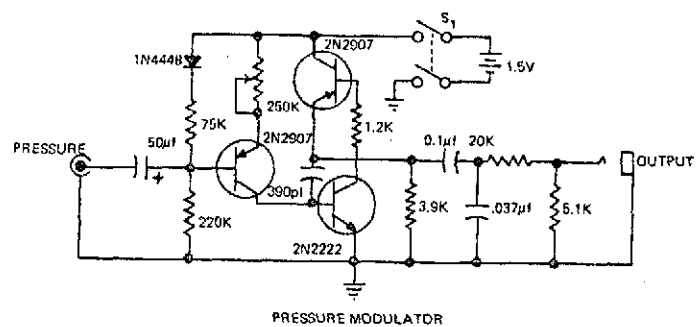
FM modulation was chosen to raise the low frequency signals to typically 2-5 kHz. This allows for rejection of AM noise and the use of FM broadcast band telemetry with a minimum of circuitry. For ease of design and cost, pulse rate modulation (PRM) was chosen over the more complicated pulse width modulation designs used in the more expensive commercial models.

### Amplifier-Modulator

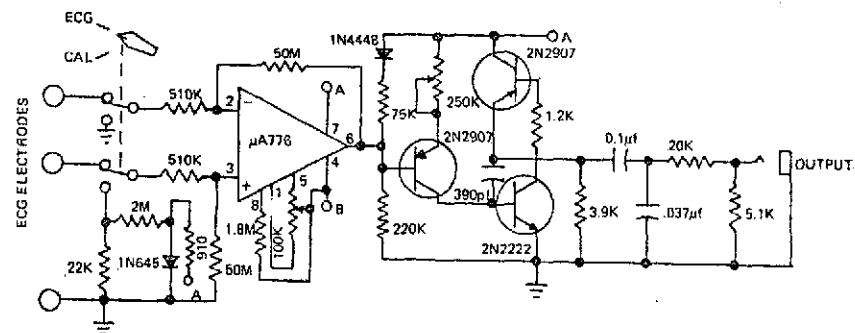
To amplify low level biopotential signals acquired by electrodes, a micropower programmable operational amplifier is utilized (Figure 2). The Fairchild amplifier is characterized by large open loop gain, high input impedance, high common mode rejection, low offset current and voltage, and very low power consumption.

As shown the amplifier has a gain of approximately 100 with an operating current of 1.5 microamps, well within the safety limits for human use. A calibration switch is incorporated to insert a reference level if desired. This signal is generated by reading the portion of the forward voltage drop ( $V_f$ ) on the diode (1N645).

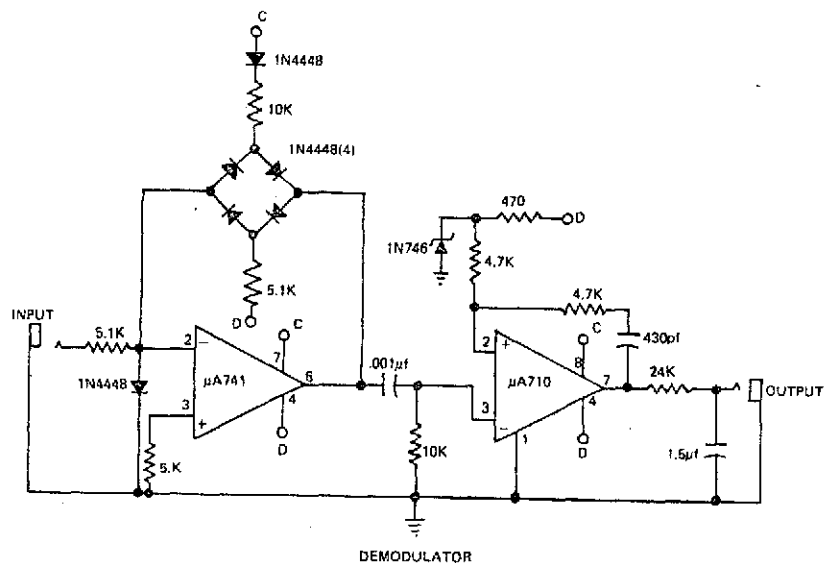
The three transistor circuit following the preamplifier and also in the pressure unit comprise the modulator. This provides a deviation sensitivity of  $\pm 10\%$  for  $\pm 10$  millivolts at the base of the input 2N2907. Collector current of this transistor is linearly related to the input voltage at the base. The 390pf capacitor is charged by this collector current and the voltage resulting from this charge in turn controls the period of the oscillator.



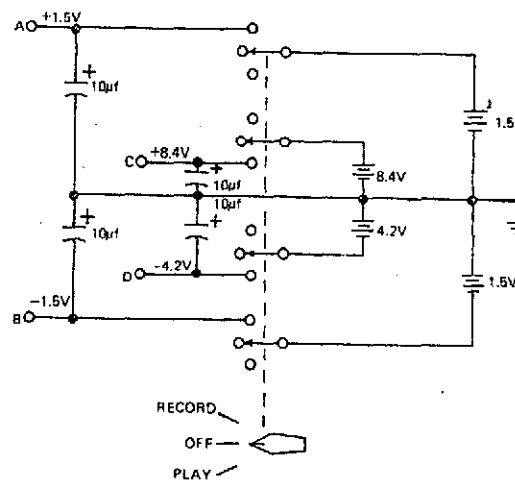
PRESSURE MODULATOR



ECG MODULATOR



DEMODULATOR



RECORD  
OFF  
PLAY

MEDICAL MONITORING WITH ECONOMICAL CASSETTE RECORDERS	
ENGR.	Robert L. Wilkins
TECH.	Menan C. Hanz
DATE	29 Sep 72
APPROVED C. H. Hanz	
#GLM- 32 & 5NM-26	

FIGURE 2. SYSTEMS SCHEMATIC

The 250 kilohm potentiometer and the 390 pf capacitor set the period of the oscillator. The time required to charge this capacitor to the potential necessary to flip the circuit is about 100 times as long as the on time established by storage-time effects. The resulting one percent duty cycle accounts in part for the low power dissipation of the circuit. The output pi filter alters the square wave into triangular waveshapes which reduces the harmonic content and produces better recordings.

To use telemetry, the same modulator is utilized. A simple transmitter (Figure 3), is added to the modulator for short range telemetry. The 250 kilohm pot sets the subcarrier oscillator frequency to approximately 2kHz.

### Demodulator

Demodulation is achieved with the zero crossing detector/one-shot multivibrator and integrator.

An output signal from the tape recorder is sampled by the zero crossing detector and provides a sharp transition for each zero crossing. These are differentiated and applied to the multivibrator. Negative triggers into the multivibrator produce positive output pulses which are smoothed by the integrator reproducing the original signal.

Component values of the differentiator and integrator are dependent upon the center frequency ( $f_0$ ) of the modulator. It is easiest to determine this empirically as the type and quality of the tape recorder will be the controlling parameter.

For time accurate demodulation, a phase locked loop is utilized (See Figure 4). The voltage controlled oscillator (VCO) in the NE561B is set at the modulator quiescent frequency by  $C_2$  and the potentiometer. The circuit will then capture signals up to deviations of  $\pm 20\%$  of the VCO frequency.



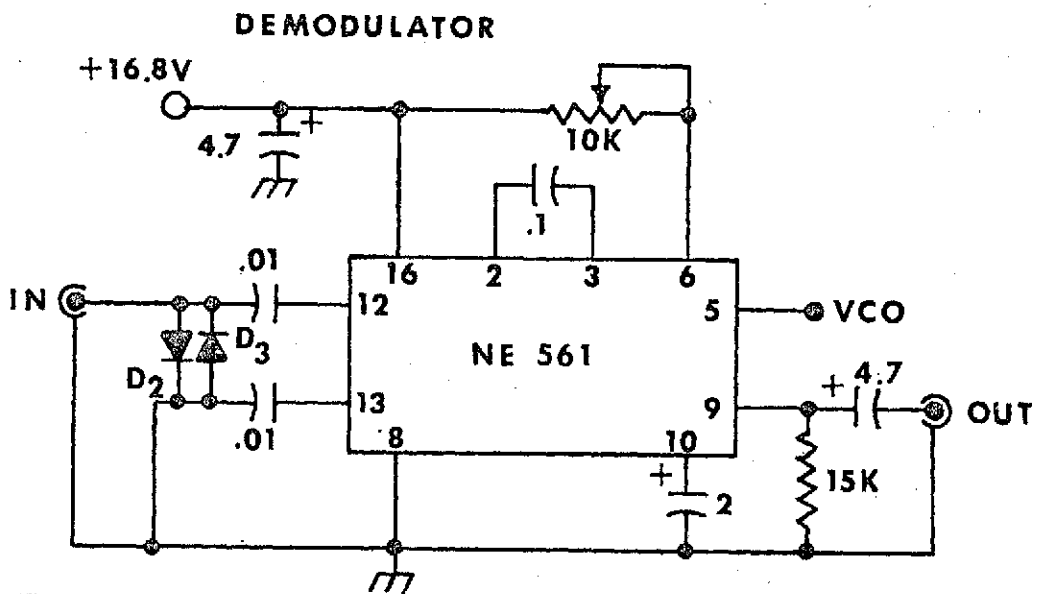


FIGURE 4

#### IV. Summary

With the values shown, the system will operate with a 2kHz center frequency, 100 Hz bandwidth and track at least  $\pm 20\%$  from center frequency and remain within 1% distortion. The signal to noise ratio measured at tape speed of 1-7/8 inches per second is 35 dB and is comparable to commercial instrumentation costing 10 times as much per channel of data.

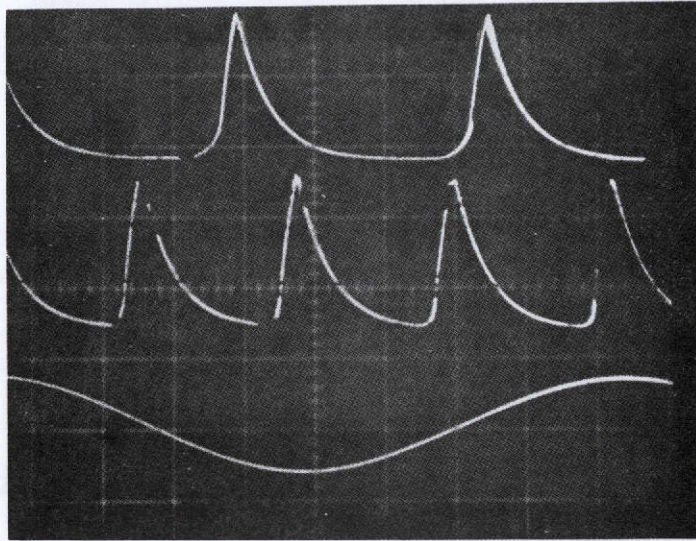
Waveshapes at selected points are shown in the Appendix.

## APPENDIX

### Selected Waveshapes of Cassette Recorder and Signal Conditioners



Photograph #1



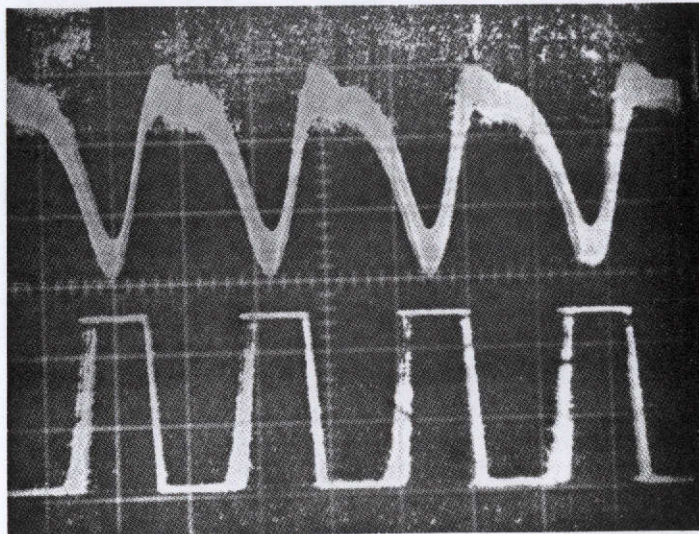
Output of SCO minimum frequency (approx. 1.6 kHz)  
 Output of SCO maximum frequency (approx. 2.4 KHz)

Horz. --.2msec/div Vert. --.1v/div

Modulating Signal 150mv .1 Hz

Horz. --1sec/div Vert. --.05v/div

Photograph #2



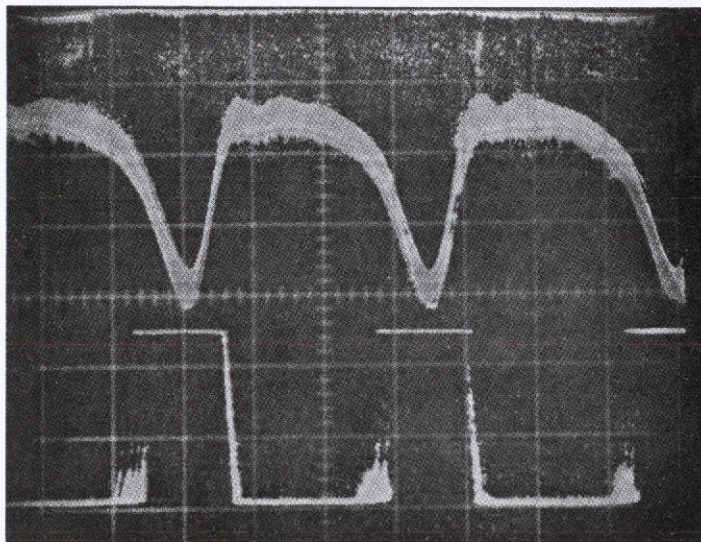
Output of Tape Recorder--Input to Zero Crossing Detector

Horz. --.2msec/div Vert. --1v/div

Output of Zero Crossing Detector--Input to Differentiator

Horz. --.2msec/div Vert. --5v/div





Output of Tape Recorder--Input to Zero Crossing Detector

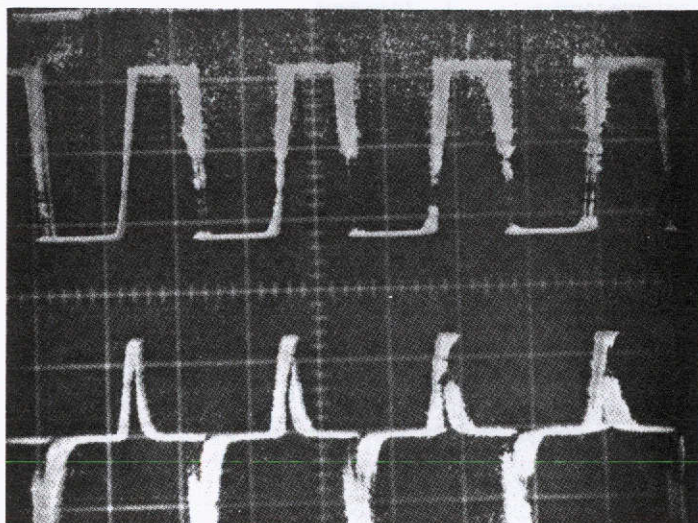
Horz. ---.2msec/div Vert. ---1v/div

Output of Zero Crossing Detector--Input to Differentiator

Horz. ---.2msec/div Vert. ---5v/div

Photo #2 shows maximum frequency and Photo #3 shows minimum frequency

Photograph #4



Output of Zero Crossing Detector--Input to Differentiator

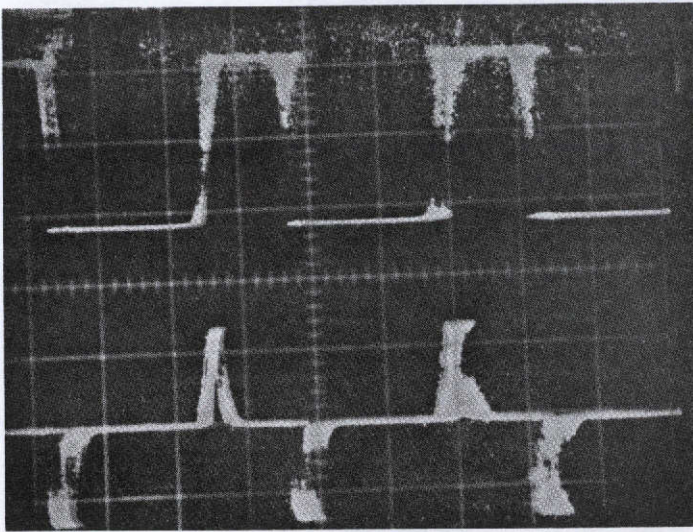
Horz. ---.2msec/div Vert. ---5v/div

Output of Differentiator--Input to Pulse Counting Demodulator

Horz. ---.2msec/div Vert. ---2v/div



Photograph #5



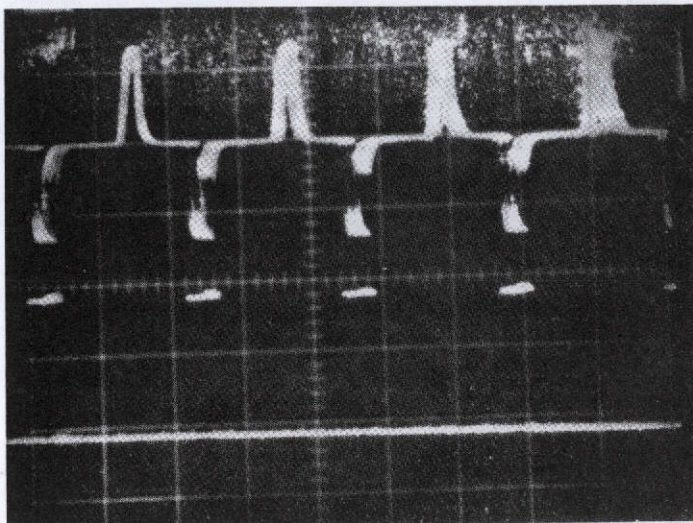
Output of Zero Crossing Detector--Input to Differentiator

Horz. ---.2msec/div    Vert.--5v/div

Output of Differentiator--Input to Pulse Counting Demodulator

Horz. ---.2msec/div    Vert. --2v/div

Photo #4 shows maximum frequency and Photo #5 shows minimum frequency



Output of Differentiator--Input to Pulse Counting Demodulator

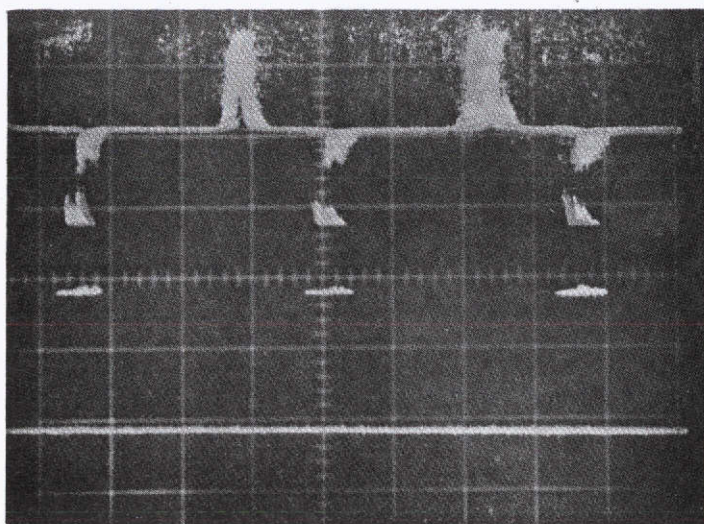
Horz. ---.2msec/div    Vert. --2v/div

Output of Pulse Counting Demodulator--Input to Integrator

Horz. ---.2msec/div    Vert. --2v/div



Photograph #7



Output of Differentiator--Input to Pulse Counting Demodulator

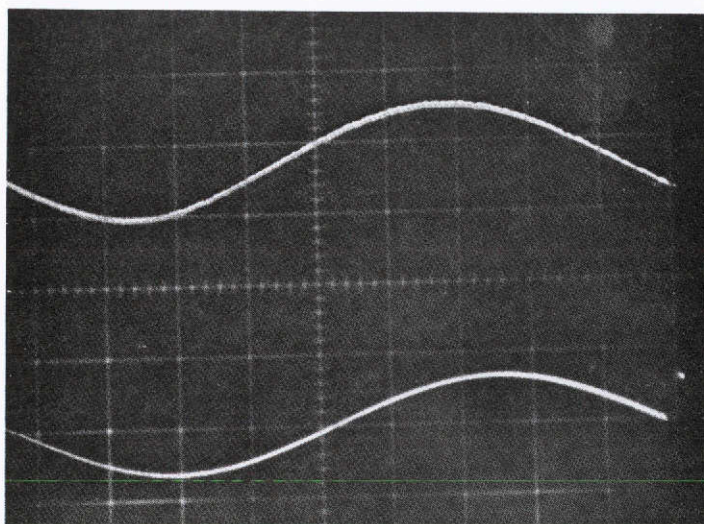
Horz. --- 0.2msec/div    Vert. --- 2v/div

Output of Pulse Counting Demodulator--Input to Integrator

Horz. --- 0.2msec/div    Vert. --- 2v/div

Photo #6 shows maximum frequency and Photo #7 shows minimum frequency

Photograph #8



Output of Integrator--Signal to Recorder

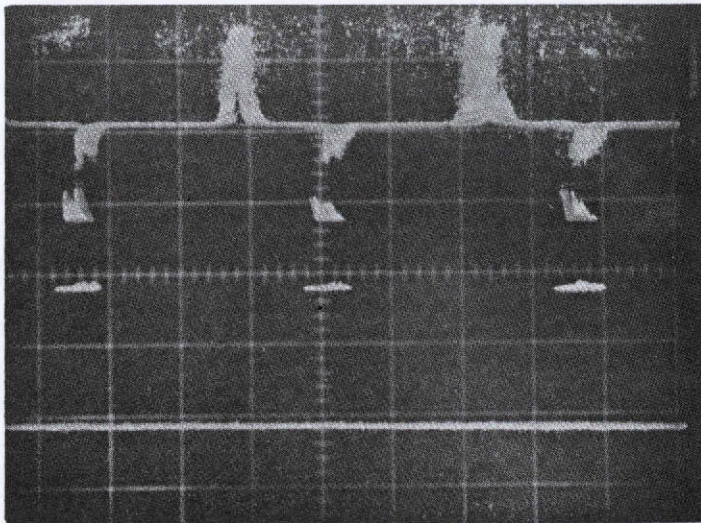
Horz. --- 1sec/div    Vert. --- 1v/div

Modulating Signal

Horz. --- 1sec/div    Vert. --- 1v/div



## Photograph #7



Output of Differentiator--Input to Pulse Counting Demodulator

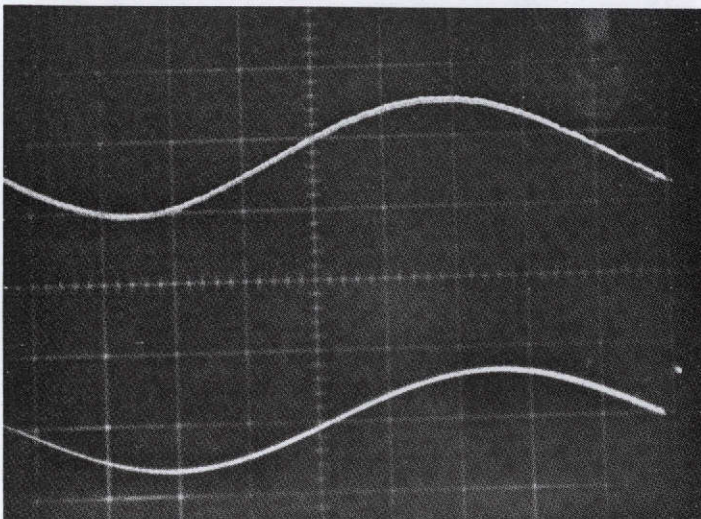
Horz. ---.2msec/div    Vert. ---2v/div

Output of Pulse Counting Demodulator--Input to Integrator

Horz. ---.2msec/div    Vert. ---2v/div

Photo #6 shows maximum frequency and Photo #7 shows minimum frequency

## Photograph #8

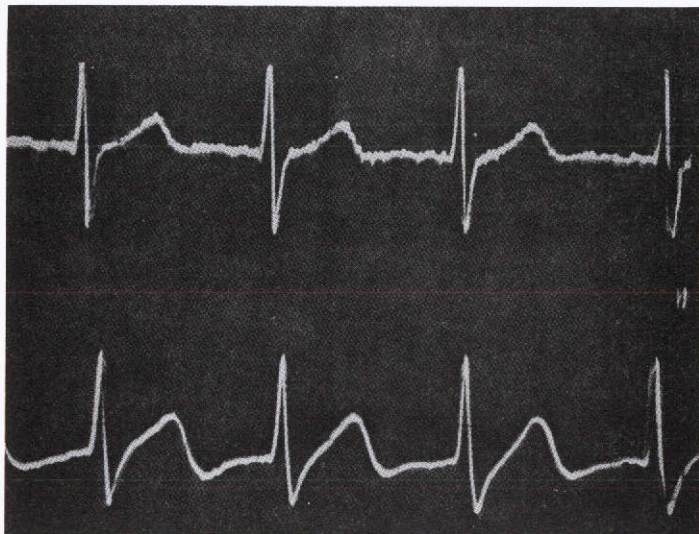


Output of Integrator--Signal to Recorder

Horz. ---1sec/div    Vert. ---.1v/div

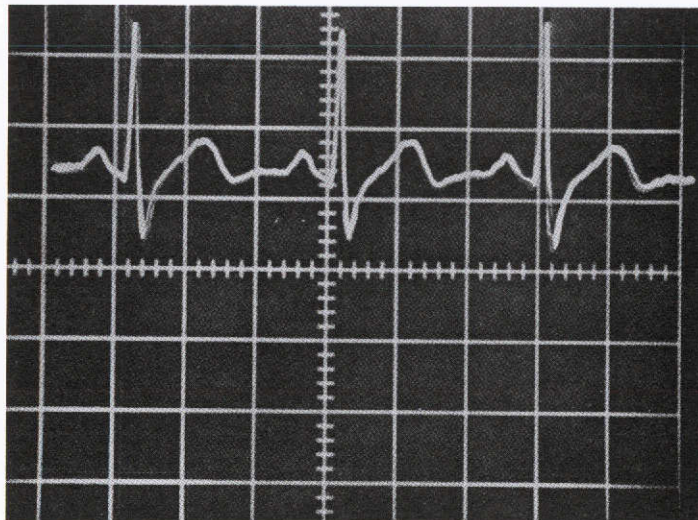
Modulating Signal

Horz. ---1sec/div    Vert. ---.1v/div



Reference  
ECG

Direct  
ECG



Telemetered  
ECG

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TECHNOLOGY APPLICATION REPORT

Problem: SWR-1 CUSTOM FITTED COMPOSITE LEG BRACE

Institution: Southwest Research Institute  
San Antonio, Texas

Investigators: J.A. Downey, M.D.  
Sam McFarland  
Glenn Grimes  
Herschel L. Bevill

Acquisition Date: February 1972 Completion Date: August, 1973

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PROBLEM OBJECTIVE

A feasibility project was initiated to determine if NASA composite materials could be suitable for the development of soft-tissue-conforming long leg braces.

BACKGROUND

Based on a idea generated out of NASA technology in composite material, the Institute launched an applications engineering development program to demonstrate that the strength, yet light-weight, of composite structures (originally developed for airframe and space vehicle applications) could be used effectively in braces or other orthopedic appliances.

RESOLUTION

The project was sustained by SwRI internal funding and resulted in a functional set of bilateral long-leg braces. The main supporting members of the braces were molded to the contour of the leg out of graphite-fiber reinforced, epoxy-matrix composite laminates. The resulting braces weigh approximately one-third of what a conventional set of stainless steel braces would.

APPLICABLE NASA TECHNOLOGY

Materials background information was provided by NASA Tech Briefs B71-10217 and B72-10294. Copies of both briefs follow this summary, along with a photograph of the braces on the subject.

## EVALUATION

The cooperating patient, a low-level quadriplegic, due to a spinal trauma sustained in an automobile accident, has to date worn the braces for over two months continuously with marked satisfaction. The braces, besides being aesthetically pleasing, are reported to measurably improve mobility due to light-weight. Continued atrophy from the time of initial contouring has caused the need for slight brace modification but does not affect the effectiveness of the brace development.





SWR-1 Prototype - NASA Developed Leg Braces



# NASA TECH BRIEF

*Marshall Space Flight Center*



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

## Promising Boron/Graphite/Resin Composites

A program was conducted to develop lightweight structural composites that would have high specific strength and stiffness and would remain effective under extreme environmental conditions. Effort was specifically directed to an analytical and experimental investigation of a specially developed, mixed (hybrid) composite consisting of boron and graphite fibers in an epoxy matrix. Emphasis was placed on the mixed composite with intermingled fibers, rather than a laminated composite with alternating layers of different preregs (combinations of resins and reinforcements in easy-to-handle sheet or other form).

As a result of this program, the following conclusions were reached:

1. The boron/graphite/epoxy mixed composite is a feasible engineering material in that it possesses excellent mechanical properties and can be easily produced within small tolerances on the constituent volume fractions.
2. Despite the improved transverse tensile modulus and in-plane shear modulus of the boron/graphite/epoxy hybrid, these improvements are not of sufficient magnitude to warrant changes in present conservative design procedures. The main benefit to be gained from this composite lies in its improved longitudinal strength and modulus. However, similar improvements can be obtained by increasing the boron volume fraction on boron/epoxy composites alone. The use of the mixed composite as a replacement for the boron/epoxy composite would be unjustified unless the fiber mixing process could be achieved at very little additional cost.
3. The most feasible applications of the boron/graphite/epoxy composite are in areas where other existing composites have shortcomings. One such ap-

plication, developed in this program, is that of transitioning the hybrid composite between relatively stiff boron/epoxy load-bearing elements and more-workable graphite/epoxy closeout sections. Two basic transition combinations of this type were fabricated and tested, and were shown to yield strong, aerodynamically smooth, adhesive-free transitions in a single curing process.

### Notes:

1. Specific technical questions may be directed to:  
Technology Utilization Officer  
Code A&TS-TU  
Marshall Space Flight Center  
Huntsville, Alabama 35812
2. The following documentation may be obtained from:  
National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.95)

### Reference:

NASA-CR-102944 (N71-14267). Boron/Graphite Hybrid Composite Development Study

### Patent status:

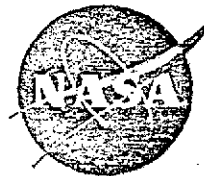
No patent action is contemplated by NASA.

Source: H. A. Evensen of  
Whittaker Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-21126)

Category 04.08

# NASA TECH BRIEF

## Marshall Space Flight Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### Graphite and Boron-Reinforced Composite Materials Data Summary

A data summary file has been assembled consisting of currently available, comprehensive information concerning graphite and boron-reinforced composite materials. The data summary is not intended to be a detailed design guide, but rather, a collection of information on typical processing techniques, mechanical properties, and physical properties of the advanced composite materials, which are being considered for structural applications on advanced space vehicles.

Information in the form of tables and graphs is provided covering shear modulus, shear strength, flexure modulus, flexure strength, stress-strain data, compressive modulus, compressive strength, interlaminar shear strength, linear thermal expansion, longitudinal and transverse tension strength, specific heat, thermogravimetric and differential thermal analysis, time-temperature-viscosity relationships, electrical resistivity, and hoop data. The effects of room temperature and elevated temperature aging or post cure are shown. Available data on many commercially available composite materials are included.

These composite materials were developed primarily

to fill aerospace industry needs, providing good strength at elevated temperatures with high stiffness and low weight. However, they will have many uses in other fields where their unique properties can be utilized, such as prosthetics and rehabilitation equipment, and marine masts, booms, and spars, etc.

#### Note:

Requests for further information may be directed to:  
Technology Utilization Officer  
Marshall Space Flight Center  
Code A&TS-TU  
Huntsville, Alabama 35812  
Reference: B72-10294

#### Patent status:

No patent action is contemplated by NASA.

Source: General Dynamics  
under contract to  
Marshall Space Flight Center  
(MFS-21691)

Category 04

TECHNOLOGY APPLICATION REPORT

Problem: TCD-9 PORTABLE AMPLIFIER SYSTEM FOR PATIENT  
WITH PARTIALLY INACTIVATED VOCAL CORDS

Institution: Texas Rehabilitation Commission  
Texas Commission for the Deaf  
Austin, Texas

Investigator: Mrs. Anne T. Kohler for  
Mr. David Myers

Acquisition Date: October, 1971 Completion Date; January, 1973

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#### PROBLEM OBJECTIVE

Investigators were in need of a battery-operated throat microphone and amplifier system which would provide voice communications in a room without a PA system.

#### BACKGROUND

Counselors for vocational rehabilitation of the deaf and hard of hearing are often concerned with concomitant problems related to speech and speech quality in communications. The conditions are frequently aggravated by or caused by illness or infections. Mumps infections and cancer of the larynx can leave conditions wherein the vocal cords are partially inactive. In such instances there exists inability to speak above soft output. Although there are relatively good commercial devices that provide portable amplification using a hand-held, throat-contact microphone, our investigators desired a portable unit, with hands-free operation that would allow sufficient voice amplification to permit speaking to groups of people in room situations where a public address system is unavailable.

#### RESOLUTION

Using a NASA developed, now commercially available, microphone headset configuration with qualities of exceptional light-weight, streamlined headset design, and distortion-free microphone output, this was properly interfaced with a fairly standard audio amplifier built into an inexpensive, portable, desk-top model for conferences, etc.

## APPLICABLE NASA TECHNOLOGY

The interface microphone originally developed for NASA use is now marketed by Plantronics, 111 Josephine Street, Santa Cruz, California 95060. An excerpt description and figure sketch of the microphone headset from the Plantronics catalog follows this summary. Suitable schematic for a reliable audio amplifier is included on the next page.

## EVALUATION

The investigator reported that the desk top model gave him the ability to communicate easily and clearly to people 40 feet away in a room. The comfort of the light-weight headset that gave hands-free use was appreciated. It should be noted here, that although the solution to this problem did not require extensive identification of technology, nor modification of same, that through the BATeam efforts novel and useful applications are being identified and made feasible to call attention to special needs of the biomedical community that have as yet not been satisfied by the commercial suppliers.

### MS40 SERIES MICROPHONE-ONLY HEADSETS

The MS40 Series headsets are equipped with a microphone only. They are general-purpose dynamic microphones. The various models differ in microphone impedance and output level, depending on the application. Each unit is supplied with a headband, personal storage pouch, and instructions.

Typical of models MS40-4, -5, -6, /T30-1.



Model No.	Typical Applications	Microphone Impedance <sup>†</sup>	Microphone Output Level <sup>‡</sup>	Operating Voltage (Nominal)	Cord Length	Termination	Notes*	Reference Figure**	Accessories Options†	List Price
MS40-4	Sound system, radio console, amateur, CB, dictation	3000 ohms	1.55 mV		5 ft.	Pigtalled		C1	BNS-1, VAA-1, PMM	\$44.95
MS40-5		150 ohms	0.275 mV							
MS40-6		5 ohms	0.05 mV							
MS40/T30-1	Aircraft (carbon replacement)	Amplifier: 50 ohms	Selectable: 17/34/67 mV	3.0 VDC at 36 ma		PJ-068	6, 7	C2	BNS-1, VAA-1, PMM, 05680	\$75.90

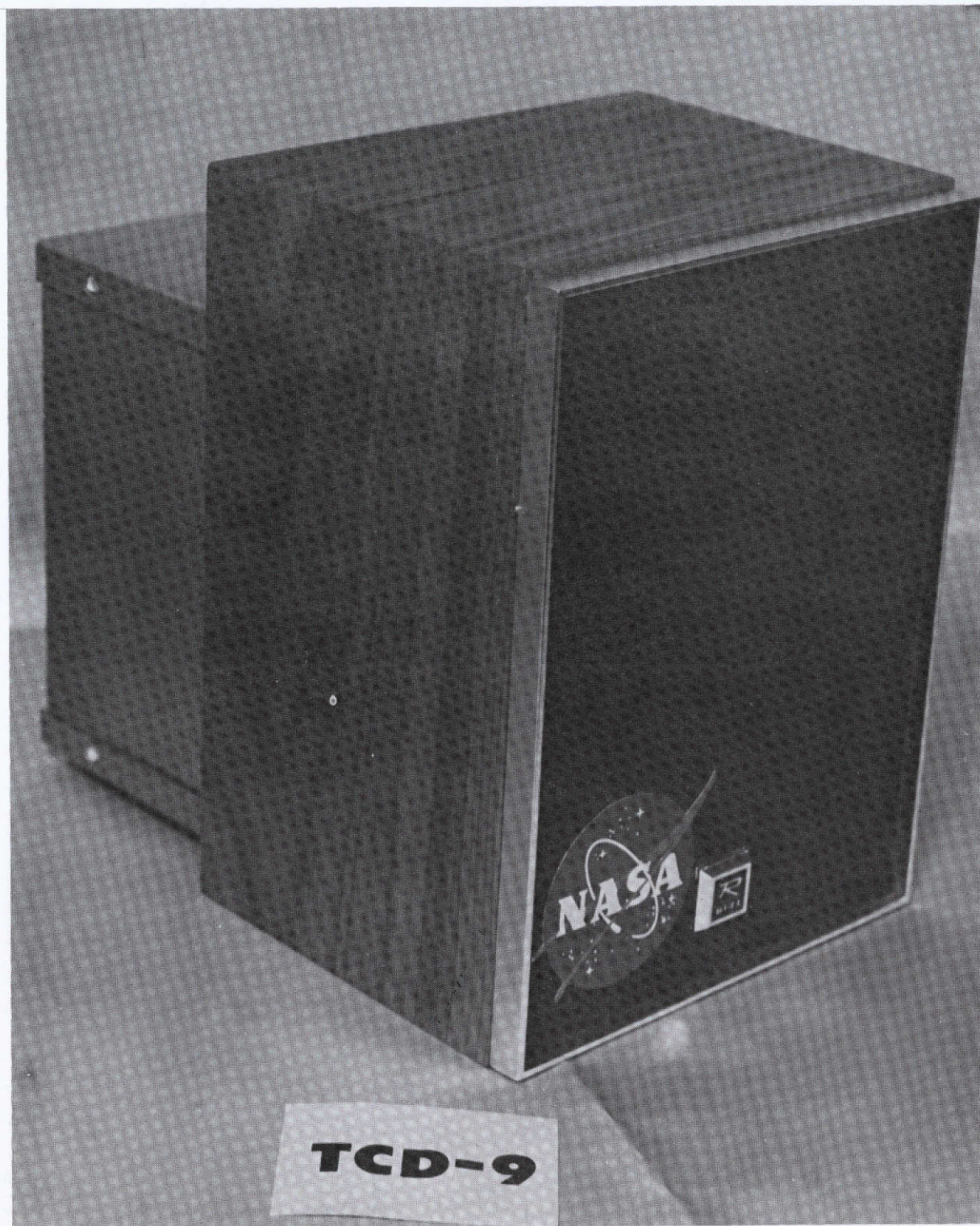
\*Refer below.

\*\*Refer to page 5.

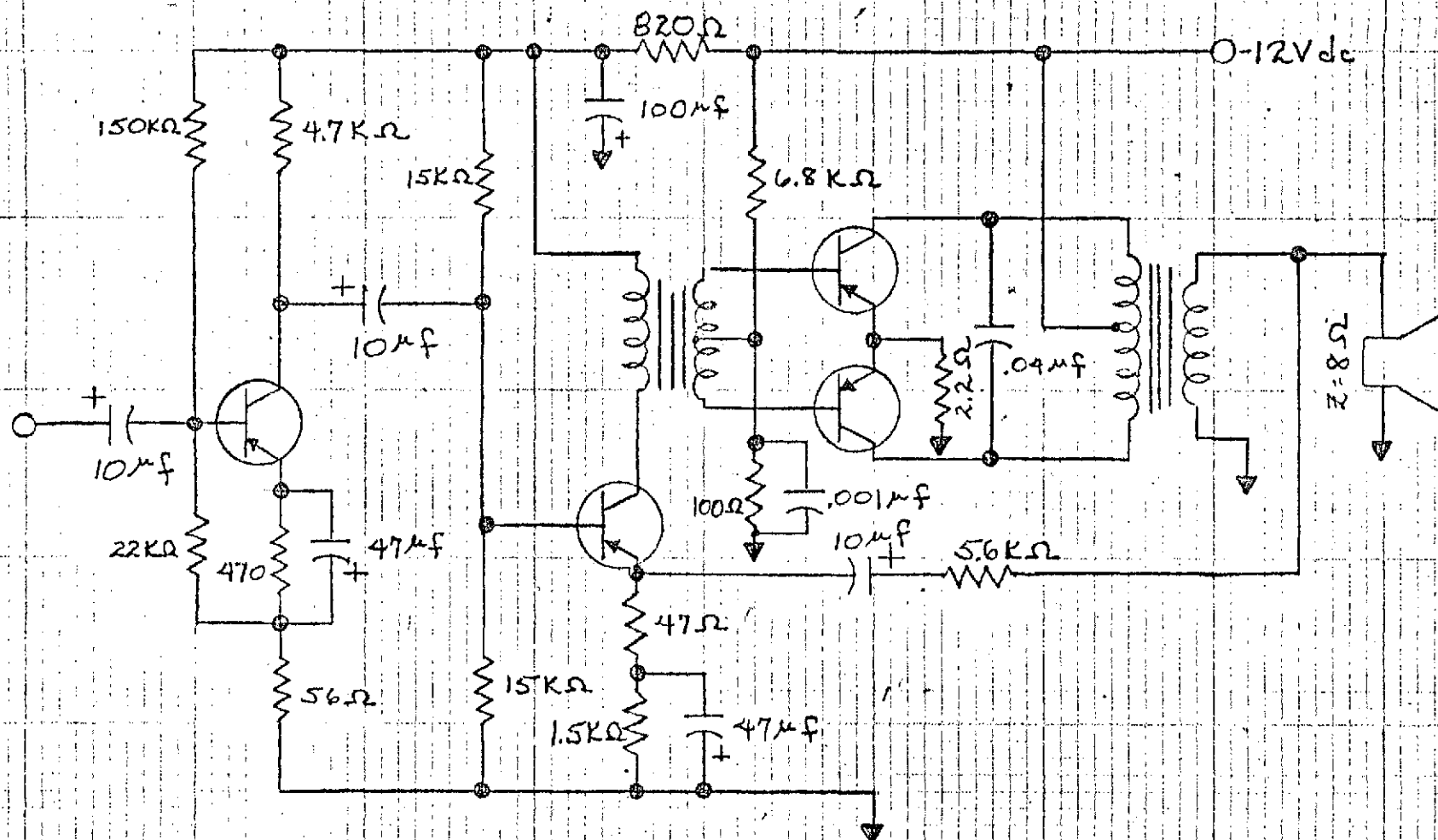
†See page 6.

Plantronics Microphone Headset  
Used for TCD-9 Voice Amplification Device





TCD-9 Desk-Top Model of the Portable  
Voice Amplification Device



REMOTE AMPLIFIER
SWRI BATEAM
R. L. WILBUR
M. HANZ
TCD-9

TECHNOLOGY APPLICATION REPORT

Problem: TVA-2 PORTABLE HEART RATE INDICATOR FOR  
ACTIVE PATIENTS

Institution: Veterans Administration Center  
Temple, Texas

Investigator: Ralph H. Hooker  
Chief, Corrective Therapy

Acquisition Date: April, 1972 Completion Date: December, 1972

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#### PROBLEM OBJECTIVE

Investigators needed a portable, miniature, durable and reliable device to be hand carried by a patient as it monitors heart rate during exercise activities.

#### BACKGROUND

During therapy work with cardiac patients, heart rate information must be gathered and the data used to determine the dosage of exercise the patient can safely take on during his recovery progress. Ward physicians determining the adjusted heart rate for these cardiac patients (eg., 60%-70%-100%) and setting safe heart rate increases were making their decisions based on manual recording of pulse rates before any exercise, immediately after exercise, and again after rest periods of 3 and 5 minutes. Portable cardiometers are commercially available, most not available for under \$2,000. And most contained extra options not needed for this program. Investigators were concerned about development of an extremely portable unit, capable of accurate and reliable measurement of heart rate, calibrated to indicate heart rates between 50 and 140 beats per minute. Above all, the unit should be cost-effective.

#### RESOLUTION

A cardiometer with telemetry option had already been developed under this year's BATEam program. Without the telemetry, not needed in this instance, the instrument will accept either electrodes or auxillary inputs to provide both meter and recorder outputs. The needed device was fabricated utilizing the technology set forth in the discussion of problem AEB-2, documented earlier in this report.



A copy of the cardiometer block diagram and a technical discussion of same follow this summary.

#### APPLICABLE NASA TECHNOLOGY

As in AEB-2, technology set forth in NASA Tech Briefs B64-10171, B65-10010, and B65-10143 were utilized for this solution. Copies of these are included under the AEB-2 summary.

#### EVALUATION

Investigators have expressed satisfaction with the cardiometer, noting the accuracy and reliability of the data gathering and the considerable man-hour savings utilizing the device. The point to be made about the undertaking of this problem is to emphatically note that even though the volume of convalescing cardiac patients is considerable, much of the needed therapy does not require extremely sophisticated equipment.

### TVA-2 Cardiometer - Technical Discussion

The block diagram of the cardiometer shows an instant pulse monitor preceded by an ECG preamp and signal conditioning circuitry. The "Select" switch allows either the direct ECG signal or an averaging-type heart rate monitor output to drive the cardiometer.

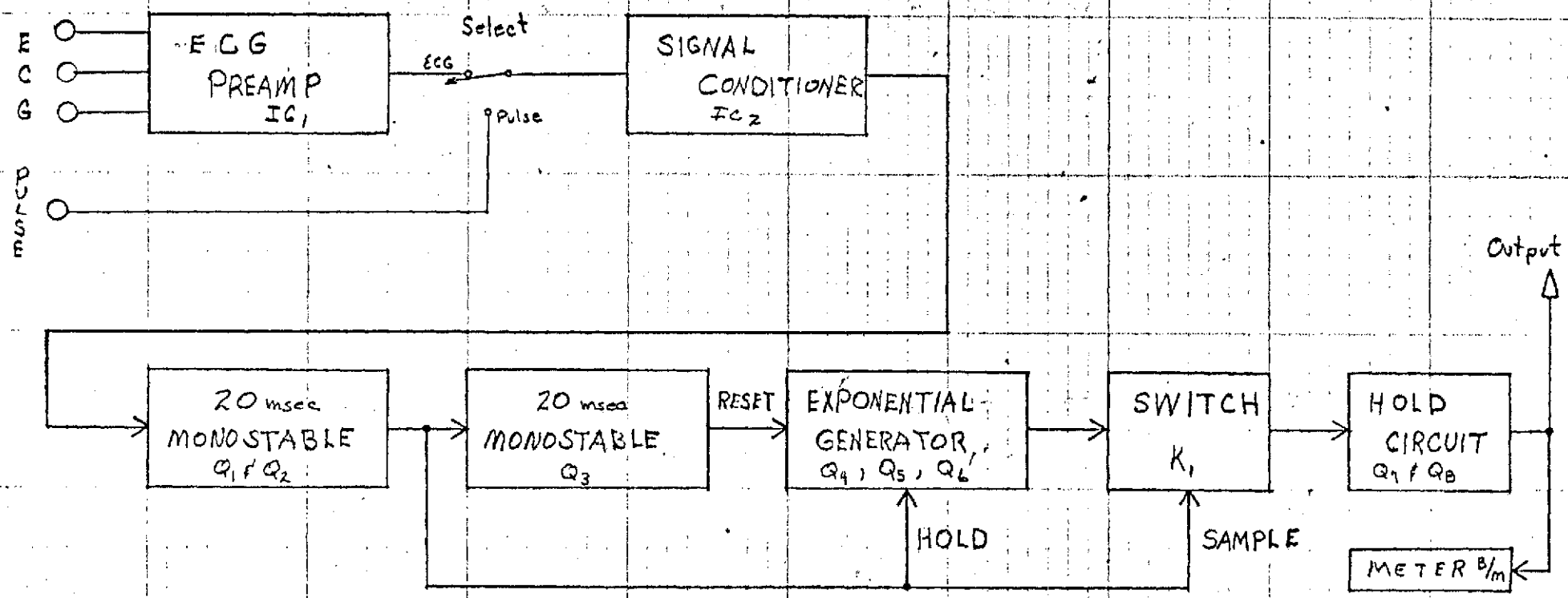
Circuit description is aided by referring to the schematic diagram. IC<sub>1</sub> is the ECG preamp and consists of a standard differential input operational amplifier circuit. Having selected the desired drive signal, its amplitude is increased to the point necessary to insure reliable operation of the conversion circuitry that follows.

Conversion from pulse interval to voltage is by means of an exponential waveform generator which is sampled then reset by each input pulse.

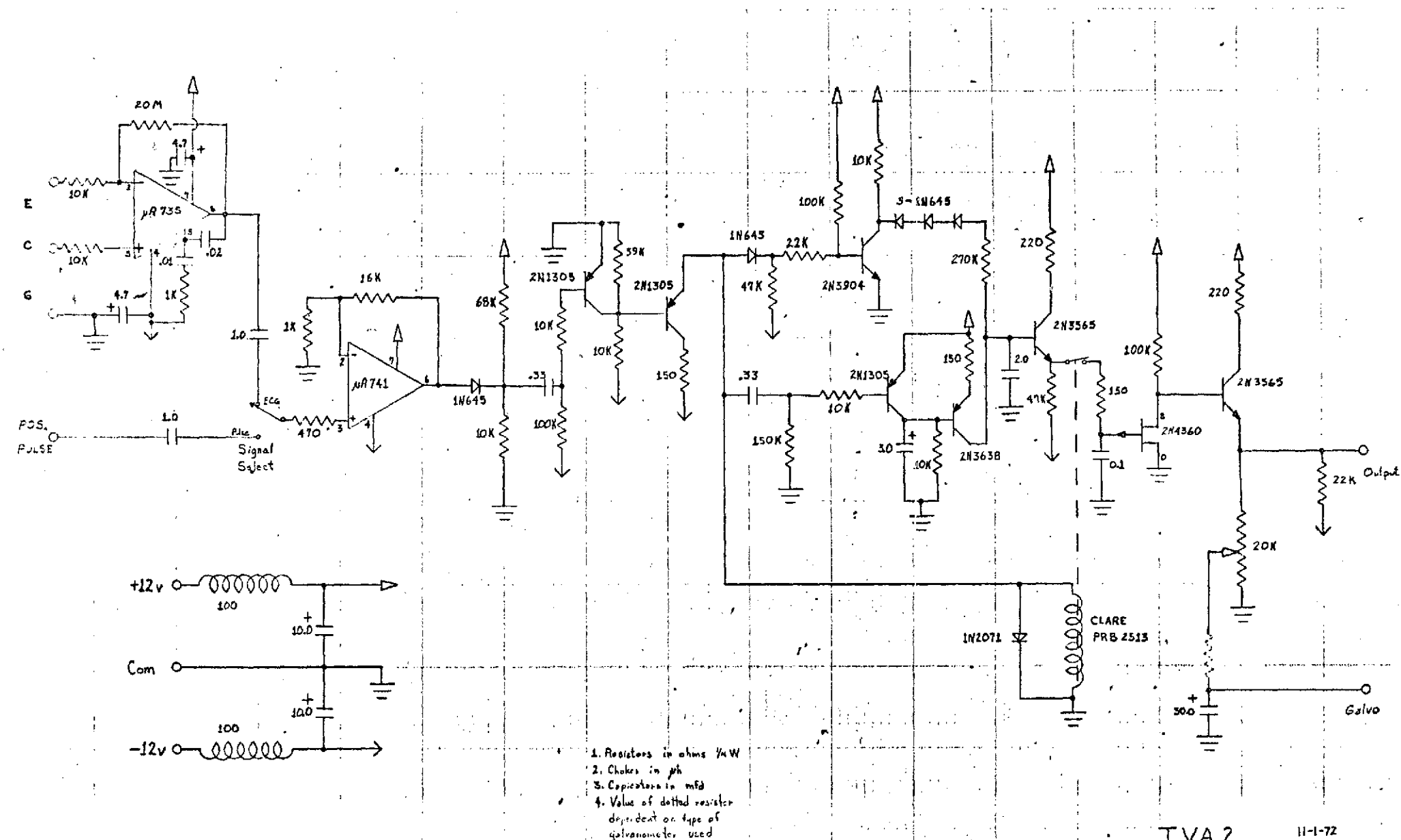
Transistor Q<sub>1</sub> is used in a simplified monostable multivibrator. A positive input pulse through diode D<sub>1</sub> turns Q<sub>1</sub> off, driving the output of emitter Q<sub>2</sub> to about -9v. This energizes relay K<sub>1</sub> so that C<sub>11</sub> is charged to approximately the same voltage as that of C<sub>10</sub>, by means of emitter follower Q<sub>6</sub>. During this sampling interval, Q<sub>4</sub> is turned off so that C<sub>10</sub> does not discharge through R<sub>23</sub>.

Also during this sampling interval, C<sub>7</sub> charges negatively, turning Q<sub>1</sub> back on. The positive transition on the emitter of Q<sub>2</sub> drives Q<sub>3</sub> off (Q<sub>3</sub> being a simplified monostable multivibrator similar to Q<sub>1</sub>), driving Q<sub>5</sub> on so that C<sub>10</sub> is rapidly charged to about +11v. C<sub>8</sub> charges negatively, turning Q<sub>3</sub> on and Q<sub>5</sub> off so that C<sub>10</sub> may discharge through R<sub>23</sub>. Q<sub>7</sub> and Q<sub>8</sub> buffer the signal from C<sub>11</sub> to provide a low-impedance output. R<sub>31</sub> is provided to permit calibration of the meter output if a galvanometer were to be substituted for the meter.

Each succeeding input pulse triggers the events described above so the output voltage is proportional to the reciprocal of the time between the most recent pair of pulses.



BLOCK DIAGRAM OF CARDIOTACHOMETER  
TYA-2/AEB-2



### 2.1.2 Information Technology Applications

Below is a list of biomedical technology applications claimed during this reporting period. On the following pages are summaries for those applications.

No.	Problem Title	Date Opened/Closed
BVA-4	Portable ECG Telemetry Receiver and Tape Recorder	04-70/01-73
FTZ-1	On-Line Breath Analyzer	12-70/08-73
HPH-3	High Altitude Effect on Hemoglobin	11-72/02-73
RNV-39	Development of Proper Procedures for Observation of Human Subjects in Medical Research	10-71/11-72
TTU-2	Bibliography on NASA's Involvement in Vigilance and Attention Monitoring	10-72/04-73
UFM-7	Methods for Computer Analysis of EEG for Health Care Cost Reduction	05-70/08-73
UTM-40	Detecting Oxygen Toxicity in the Lung	11-72/09-73
UTM-44	Detection/Measurement of Microbubbles or Microthrombi in the Blood	11-72/09-73
VAL-3	Computer Applications in Hospitals-A Practical Criteria Collation	04-73/08-73
WMC-1	Plethysmographic Data Interface System	10-72/06-73

## INFORMATION TECHNOLOGY APPLICATION REPORT

Problem: BVA-4 PORTABLE ECG TELEMETRY RECEIVER AND  
TAPE RECORDER

Institution: Veterans Administration Hospital  
Bay Pines, Florida

Investigator: Thomas M. Dunn, M.D.  
Chief of Surgery

Acquisition Date: April, 1970 Completion Date: November, 1972

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### PROBLEM OBJECTIVE

The investigator needed a portable, hand-carried receiver-recorder for ECG data collection of ambulatory convalescing cardiac patients. These patients are located at different sites across the institution's facilities, making regular checkups extremely time consuming. Commercial ECG data collection systems are heavy and do not have telemetry capabilities.

### BACKGROUND

The convalescence regimen prescribed for cardiac patients at this institution require them to be occupied in a variety of activities at several sites in the hospital complex. Many of the activity sites are not close to available electrocardiograph equipment. This has made necessary the hospital staff's visitation with the patients in the remote locations to determine their physical condition.

The investigator sought a method of quantitatively evaluating these convalescing cardiac patients. He needed a system to monitor the ECG transmitter on each patient, and a receiver-demand-recorder to permit data retrieval by a staff member.

### RESOLUTION

It was determined that NASA/BATeam technology already developed (i.e., the GLM-32 ECG recorder and the SNM-26 pelvic pressure monitor) would be applicable. BATeam engineers suggested the addition of a small, portable strip chart recorder to the

NASA device for a complete instrumentation package which met all specifications of the investigator.

The complete system monitors ECG, GSR, EEG, temperature, or pressure by hard-wire connections or telemetry to a cassette recorder. Once the information is stored on the magnetic tape, the system also demodulates the digitized data for analog presentation. The entire system is designed for fabrication into the carrying case of the recorder, maintaining the portability feature.

Because of the similarity of this development to already developed BATEam hardware, and because of lack of funding priority, the hardware for the system was never developed. The investigator was, however, furnished with complete instructions, schematics, and as much information as possible in order that he could arrange for fabrication of the system at his facility.

#### APPLICABLE NASA TECHNOLOGY

As in Problem SNM-26 documented earlier in this report, the NASA Tech Brief B64-10171 was used as a basis. The Technical Support Package for SNM-26 also applies to this problem and includes supporting technical descriptions, etc.

#### EVALUATION

This particular investigator, in addition to his physician status, has extensive electrical engineering background and was readily able to evaluate the information provided to him. He felt at the time the solution was ideal, and was attempting to acquire funds to equip his hospital with a telemetry model of the system.



INFORMATION TECHNOLOGY APPLICATION

Problem: FTZ-1 ON-LINE BREATH ANALYZER

Institution: Fitzsimmons General Hospital (Army)  
Denver, Colorado

Investigator: David R. Hazlett, M.D.

Acquisition Date: December, 1970 Completion Date: August, 1973

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## PROBLEM OBJECTIVE

The investigator is in need of an accurate, reliable on-line breath analyzer for identification of the contents of expired air.

## BACKGROUND

The investigator is currently chief of one of the U.S. Army's major pulmonary function research programs. The basic goals and interest areas of the programs are as follows:

1. The effects of sickle cell anemia
2. The effects of fat content on lung function
3. Lung compliance
4. Development of a simplified diagnostic tool for pulmonary checkups.

Among his hardware requirements was a need for an on-line breath analyzer which could determine carbon dioxide, nitrogen, and oxygen concentrations in expired air.

## RESOLUTION

The BATeam identified and supplied a large quantity of information which proved useful. Three breath analyzers, now commercial, were identified as clinical adaptations to original NASA projects:

1. The MGA-1100 Medical Gas Analyzer, a commercial version of the Perkin-Elmer developed Skylab metabolic analyzer; (Medical Instruments, Perkin-Elmer Corp., 2771 North Garey Ave., Pomona, California 91767, (714) 593-3581.

2. The Astronaut Breath Analyzer (Analog Technology Corporation, 3410 East Foothill Blvd., Pasadena, California 91107, (213) 449-8440). (N70-25476)
3. The Miracle II, a respiratory analysis system currently under development for NASA by Quantum Dynamics which measures respiratory flow phenomena. (Quantum Dynamics, P. O. Box 865, Tarzana, Calif.) (N72-20113)

Due to the investigator's limited facilities, he was not able to evaluate the first two systems which utilize a mass spectrometer in their measurements. He is currently acquiring a small computer for data reduction and analysis purposes. With the computer availability, the investigator will be able to evaluate one of the systems.

In addition, numerous articles of interest were also identified and supplied. A sample bibliography of some of those references follows this summary. These included articles on continuous measurement of gas exchange and respiratory functions; Lockheed Respiratory Measurement Element developed for the NASA Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS); and analysis of quiet spontaneous breathing measured by spirometers and electrical impedance plethysmographs.

#### EVALUATION

To quote from the investigator: "The literature made available by your service has permitted this laboratory to perform the following single breath tests: residual volume, total lung capacity, residual to total lung capacity ratio, inspiratory capacity, and expiratory reserve volume, all determined by a single breath helium method. It also permitted determination of diffusion of a gas through a gas during estimation of stratified inhomogeneity determination from the same gas during single breath test held for various periods of time. Furthermore, this literature has permitted the development of methods for measuring single breath diffusion capacity, membrane diffusion capacity and capillary blood volume using carbon monoxide. It also permitted measurement of lung tissue volume and cardiac output using acetylene."

The investigator is now working with local engineers to develop a system fast enough to make the above mentioned measurements continuous during rest and exercise.

In addition, efforts are being made to identify the system which would best interface with the investigator's facilities in order to provide a clinical evaluation of the NASA developed breath analyzers.

The following sample bibliography of articles located and provided for FTZ-1 is only a portion of total material provided:

1. "A model for the elastic properties of the lung and their effect on expiratory flow," Lambert, Rodney K., et al, in J OF APPLIED PHYSIOLOGY., 34:1 Jan, 1973, p. 34 begin.
2. "Limits to arterial nitrogen tension in unevenly ventilated and perfused human lungs," Wiener, F., et al, in J OF APPLIED PHYSIOLOGY, 23:4, Oct. 1967, p.439 begin.
3. "Effects of time-varying blood flow on oxygen uptake in the pulmonary capillaries," Crandall, Edward D., et al, in J OF APPLIED PHYSIOLOGY, 23:6, Dec., 1967, p.944 begin.
4. "Optimization of the Oxygen Transport System," Pennock, B., et al, in BIOPHYSICAL J, 8, 1968, p.879 begin.
5. "Nonuniform pulmonary diffusing capacity measured by sequential CO uptake and washout," Mittman, Charles, in J OF APPLIED PHYSIOLOGY, 23:1 131-138. 1967.
6. "A phase method of calculating respiratory mechanics using a digital computer," Hilberman, Mark, et al, in J OF APPLIED PHYSIOLOGY, 32:4, Apr., 1972, p.535 begin.
7. "Clinical evidence of cardiac weakness and incoordination secured by simultaneous records of the force BCG and carotid pulse derivative and interpreted by an electrical analogue," Starr, Isaac, et al, in AMER HEART J, 85:3 p. 341-348, Mar 1973.
8. "Can the distribution of inspired gas be altered," Young, A.C., et al, in J OF APPLIED PHYSIOLOGY, 24:2 Feb, 1968, p.129 begin.
9. "Recording of second time derivative V of displaced volume V in breathing," by Bargeton, D., et al, in J OF APPLIED PHYSIOLOGY, 34:2, Feb, 1973, p. 259 begin.
10. "Interaction Model between the Circulatory and Respiratory Systems," Albergoni, V., et al, in IEEE TRANS ON BIOMEDICAL ENGR, Vol. BME-19, No. 2, March, 1972, p. 108 begin.
11. "Cardiovascular System Simulation in Biomedical Engineering Education," Rideout, Vincent C., in IEEE TRANS ON BIO-MEDICAL ENGR, Vol. BME-19, No. 2, March, 1972, p.101 begin.
12. "Finite element displacement analysis of a lung," Matthews, F.L., et al, in J BIOMECHANICS, 1972, vol.5, p.591 begin.

13. "The Cardiovascular Thoracic Air Plethysmogram, Verdouw, P.D., et al, in Ballistocardiography and Cardiac Performance, Proc., 11th annual meeting of the Ball. Res., Soc., Atlantic City, 1966, Bibl. cardiol. 19:63-67 (Karger, Basel. New York, 1967)
14. "Significance of the Bohr and Haldane Effects in the pulmonary Capillary," by M.P. Hlastala, in RESPIRATION PHYSIOLOGY (1973) 17, 81-92; North Holland Publishing Company, Amsterdam.

The following recent aerospace documents were also suggested for reference:

15. A71-17604 (p0142) "Lipid peroxidation in pulmonary hyperoxia, noting effects of hyperbaric oxygen, ascorbic acid and ferrous iron."
16. A72-11259 (p0014) "Inspiration time correction factor for pulmonary diffusing capacity measurement by single breath method."
17. A72-12515 (p0031) "Lung ventilation nonuniformity determination by single calm breath method, showing nitrogen concentration in alveolar phases."
18. A72-15222 (p0070) "Pulmonary RC network and multiple breath nitrogen washout time constants mathematical relationship for breathing mechanics measurement, discussing lung compliance and resistance."
19. A72-17174 (p0104) "Single breath method for pulmonary diffusing capacity measurement with respect to total lung capacity and inspiration time."
20. A72-26620 (p0272) "Digital computer techniques for computation of pulmonary mechanics parameters, using phasor method and Fourier series analysis of respiratory flow signals."
21. A72-36573 (p0426) "Rat pulmonary lipid metabolism during feeding and fasting from studies of lung lecithin half life after C-14/palmitate and H-3/U/glucose injection."
22. A72-40423 (p0490) "Evaluation of cardiopulmonary function and work performance in man during caloric restriction."
23. A72-40427 (p0491) "A method for spirographic display of functional residual capacity and other lung volumes."

24. A72-40428 (p0491) "Electrically sensed changes in chest and abdomen diameter for tidal volume, respiratory frequency and minute ventilation measurements."
25. A72-44598 (p0551) "Determination of the diffusional capability of lungs by the method of delayed respiration."

# INFORMATION TECHNOLOGY APPLICATION REPORT

Problem:            HPH-3   HIGH TO LOW ALTITUDE EFFECTS ON  
                                       HEMOGLOBIN

Institution: Hollywood Presbyterian Hospital  
Los Angeles, California

Investigator: Charles O. Bechtol, M.D.

Acquisition Date: November, 1972    Completion Date: February, 1973

## PROBLEM OBJECTIVE

The investigator deals with a large number of surgical patients who come to him from high altitude areas in Mexico. He was extremely concerned about the possible thromboplebitic complications that could occur in these patients during their convalescent period in the low altitude of Los Angeles. He wanted to know if NASA could help him to make a clinical decision as to whether or not it would be helpful to create simulated high altitude environments for his patients.

## RESOLUTION and EVALUATION

A NASA data bank search was performed. The NASA STIF search was dated November 9, 1972 , numbered T610, and it can be reproduced with updates for interested persons through the BATeam.

The investigator screened the search and a selected list of documents and articles were obtained for his use. The provided information led him to the conclusion that "any attempts to increase the hemoglobin concentration of his patients by a simulated high altitude period would not be sufficiently successful to be worthwhile. Secondly, it is evident that the patients coming from high altitude should not be at sea level for any great length of time since their hemoglobin will rapidly drop during this period. Third, and perhaps most important, are the problems related to thrombophlebitis which occur with the blood concentration which develops at high altitude." He further stated, "The patients who now come to me from Mexico will be watched with unusual care because of the increased danger of this serious complication."

A bibliography of the articles used from the NASA search follows here:

1. A67-80379 66/08/00 8 pages Unclassified Document  
"Irradiation-induced disorders of erythropoiesis as influenced by hypoxia accompanied by blood loss," by J. Neuwirt, et al, in CESKOSLOVENSKA PATOLOGIE, Vol. 2, August, 1966, p. 169-176.
2. N66-31395# Issue 18 Page 3478 Category 4 66/01/04, 5 pages "On the problem of hemopoietins under the conditions of the high mountains," by Yu B. Bobodzhanov, In: Air Force Systems Command, Wright-Patterson AFB, Ohio in its Problems of Physiology and Pathology of the High Mountains, pages 70-74, January 4, 1966. Refs.
3. "Effects of High Altitude/Oxygen Lack," by C.S. Houston, in MEDICAL CLIMATOLOGY, Physical Medicine Library, 8:257-279, 1964.
4. "Iron metabolism in the polycythemia of high altitudes," by R. Lozano, in C-E-I-R, INC., Arlington, Virginia; School of Aviation Medicine, Randolph AFB, Texas, September, 1958., 20 pages.
5. "A comparative evaluation of the effectiveness of different schedules of adaptation to hypoxia," by F.V. Babchinsky, in AZTEC SCHOOL OF LANGUAGES, Inc., Maynard Mass. (Research Translation Division) in its PROBLEMS OF SPACE BIOLOGY, 8:134-41, July 1969.
6. "Humoral control of erythropoiesis at altitude," by C. Reynafarje, In EXERCISE AT ALTITUDE, p. 171-178, 1967 - International Symposium, Milan, Sept. 29-Oct.2, 1966.
7. "Blood regeneration following loss of blood in animals acclimatized to high altitude," by A. A. Almerekova, in JOINT PUBLICATIONS RESEARCH SERVICE, Washington, D.C. August 31, 1965.



## INFORMATION TECHNOLOGY APPLICATION

Problem: RNV-39 DEVELOPMENT OF PROPER PROCEDURES  
FOR OBSERVATION OF HUMAN SUBJECTS  
IN MEDICAL RESEARCH

Institution: Rancho Los Amigos Hospital  
Downey, California

Investigator: Jack D. Hackney, M.D.  
Director  
Environmental Health Lab

Acquisition Date: October, 1971 Completion Date: November, 1972

### PROBLEM OBJECTIVE AND BACKGROUND

The investigator asked what NASA had to provide the community with on technology and methodology relating to practices, policies, and protocol appropriate to medical research with human subjects. He is involved in an extensive research efforts to investigate the effects of air pollutants on physiology and pathology processes. Professional human subjects are to be involved in these controlled studies. Input was needed to resolve problems affecting the experimental design and data interpretation when trained, professional human subjects are employed. The investigator wanted to be able to rule out false negative responses if highly motivated subjects were able to overcome mild environmental stress. They anticipated that less noisy baseline data from the trained subjects could filter out some sensitive responses.

### RESOLUTION AND EVALUATION

In specific areas of test subject policy, NASA is by the nature of its pioneer aerospace development, heavily involved in setting and developing standards of safety, hazards, effects and tolerances. In any one of these specific areas, sufficient documentation exists for volumes of information. What we were concerned about were legal, moral, and ethical problems to be considered in general.

For this particular problem, hand searching and specific NASA Center contacts proved most helpful. To the investigator's enthusiastic response for their usefulness, a selected bibliography and several documents were provided. That same listing is included here for report documentation.

1. N72-24093, "The Public Health Service Guidelines: Governing Research Involving Human Subjects: An Analysis of the Policy-Making Process, by M.S. Frankel, February, 1972, 66 pages.

Official Abstract: "This paper focuses on the policy-making process which led to development of the Public Health Service Guidelines governing research involving human subjects. Part I examines the evolution of PHS Guidelines, tracing 1) evolution of thought and legal interpretation regarding research using human subjects; 2) initial involvement of the Federal government; 3) development of the government's research program; 4) the social-political environment in which formal government policy was developed; and 5) various policy statements issued by the government. The author relies primarily upon PHS-NIH records and interviews/correspondence with key decision-makers for his historical record. Part II analyzes the process by which PHS Guidelines were developed and examines the values and other underlying factors which contributed to their development. The author concludes that the evolution of the Guidelines is best understood within the context of a "mixed-scanning strategy." In such a strategy, policy-makers make fundamental decisions regarding the basic direction of policy and subsequent decisions are made incrementally and within the contexts by the original fundamental decisions."

Dr. Sam L. Pool at Johnson Space Center in Houston provided the BATEam with a selected reference listing:

2. ETHICS AND CLINICAL RESEARCH, Henry K. Beecher, M.D.
3. HUMAN EXPERIMENTATION, Frank W. Hartman, M.D.
4. CONSENT IN CLINICAL EXPERIMENTATION: MYTH AND REALITY, Henry K. Beecher, M.D.
5. THE LAW AND HUMAN EXPERIMENTATION, William J. Curran, LL.M., SM HYG.
6. ETHICAL ISSUES IN RESEARCH WITH HUMAN SUBJECTS, Wolf Wolfensberger
7. "Conduct of Hazardous Human Experiments", Headquarters, Air Research and Development Command, Andrews Air Force Base, 12 September 1958.
8. SOME GUIDING PRINCIPLES FOR CLINICAL INVESTIGATION, Henry K. Beecher, M.D.

In regard to specific technology and methodology for the air pollutant research project in progress the BATeam suggested the following references:

9. A71-13000 (p0076) "Biological and medical cybernetics approach to closed systems construction for continuous automatic monitoring and control of human physiological processes under harmful conditions."
10. A71-17607 (p0143) "Personnel selection for emotionally and physically taxing situations by studying physiological responses to anticipated stressors and stress recovery."
11. N71-17237 (p0221) "Conference on biometrics noting human psychic and physical stress."
12. N71-17241 (p0221) "Psychological stress and bioinstrumentation."
13. N71-18256 (p0227) "Effect of physical and symbolic stressors on perceptual mechanisms."
14. N71-22306 (p0334) "Physical exercise effects on stress tolerances of trained and untrained subjects."
15. N71-27176 (p0431) "Muscular fatigue and nervous tension measurements for determining physical work fatigue."
16. N71-28260 (p0441) "Gaseous impurities in air exhaled by humans under extremal stress factors."
17. N71-35236 (p0612) "Analysis of psychological and physiological variables for predicting human performance during extended periods of stress."
18. A71-27876 (p 0354) "Space flight factors effects on human physiology and psychology, discussing spacecraft gaseous medium control, food supply, closed ecological systems and weightlessness effects."
19. A71-36945 (p0491) "Mental reactive exertion increase phenomenon, investigating achievement under various degrees of carefulness and fatigue."
20. N71-28549 (p0446) "Manual for human psychometric data acquisition and human reactions to psychological stress in Tektite project."

INFORMATION TECHNOLOGY APPLICATION

Problem: TTU-2 NASA BIBLIOGRAPHY ON ATTENTION  
AND VIGILANCE MONITORING

Institution: Texas Tech University  
Lubbock, Texas

Investigator: Charles Halcomb, Ph.D.  
Chairman, Experimental Psychology

Acquisition Date: October, 1972 Completion Date: April, 1973

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## PROBLEM OBJECTIVE AND BACKGROUND

The investigator needed support from NASA to assimilate as much substantive documentation and evidence as possible on attention and vigilance monitoring to assist in studies and proposal writing to lend weight to program continuance. Much of the work done by NASA is not available to open literature, but would be of great benefit in helping the investigator to justify involvement in developing his own equipment for vocational assessment apparatus for the physically and culturally handicapped person. His work includes learning disorders assessment in both normal and mentally retarded people. The NASA literature would also help in attempts to define a general purpose vocational evaluation procedure for placement of handicapped personnel into today's more highly complex psychomotor skills required job situations.

## RESOLUTION AND EVALUATION

A comprehensive NASA data bank search was performed with a yield of 537 citations. For reproduction and update purposes, refer for the NASA STIF search no. T0671. The investigator reported a high number of relevant citations and intends to utilize and refer to the extensive material both for program bibliographies and for use as information supplementation in building his own psychomotor skills units.

## INFORMATION TECHNOLOGY APPLICATION

Problem: UFM-7 METHODS FOR COMPUTER ANALYSIS OF  
EEG FOR HEALTH CARE COST REDUCTION

Institution: University of Florida Medical School  
Gainesville, Florida

Investigator: Jack Smith, Ph.D.

Acquisition Date: May, 1970 Completion Date: August, 1973

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### PROBLEM OBJECTIVE AND BACKGROUND

As part of their large community service provided by the University of Florida Hospital, investigators requested NASA information on computer analysis of the EEG for large scale mass screening tests to determine which patients required further medical attention and in what areas each patient needed help. Computer analysis of EEG tests would significantly reduce cost and increase speed. The University of Florida has technical capabilities for following through with the extensive material NASA could offer.

More specifically, the investigators were looking for computer techniques which assist:

1. Sleep staging
2. Detection of Phasic Events in Sleep or Abnormal EEG's Monitoring Vigilance Leads
3. Analysis of period events in the EEG

### RESOLUTION AND EVALUATION

Working directly with James D. Frost, Jr., a leading figure in NASA's development of sleep analysis techniques, instrumentation, and computer programs, the investigator was provided with the following documentation:

1. "A Simple Electronic Method for Graphing EEG Sleep Patterns," Frost, J.D., Mulsby, R.L., and Graham, M.H., in ELECTROENCEPH. CLIN. NEUROPHYSIOL. 21:501-503. 19-6 (APL 01889)

2. "An Automatic Sleep Analyzer," Frost, J.D., Jr., in ELECTROENCEPH. CLIN. NEUROPHYSIOL. 29:88-92, July 1970. Contract NAS 9-9418. (A70-35606) (APL 01724)
3. "Three-Dimensional Selective Amplitude Histograms: A Statistical Approach to EEG-Single Neuron Relationships," Frost, J. D., Elazar, Z, in ELECTROENCEPH. CLIN. NEUROPHYSIOL. 25:479-503, 1968. (APL 00221)

The BATeam also suggested that the information in the following documents could be of help:

4. A72-10073 (p0001) "EEG parameters estimation and statistical uncertainty calculation by computer program."
5. A72-19307 (p0152) "Computerized EEG data acquisition and transmission system for large hospitals with multiple critical care patient monitoring units, noting telephone access from outside."
6. A72-26679 (p0274) "EEG measurement of sleep behavior patterns, discussing sleep stages, temporal patterns, circadian rhythm, intrasleep process stability and age factor."
7. A72-33560 (p0376) "Biotelemetry and computer analysis techniques for sleep states and wakefulness studies during aerospace flight."
8. N72-12035 (p0082) "Modified pattern recognition of EEG for use on digital computer to determine sleep stage."
9. N72-21061 (p0314) "Characteristics of heart rate information during sleep, and extracting sleep information from heart rate data."
10. A71-32449 (p0411) "Computerized assistance in EEG analysis and interpretation, describing computer program for time and effort reduction in EEG reporting."
11. A71-20746 (p0205) "Correlation and spectrum analysis of simultaneous EEG data in mono and dizygotic twins using computer and FFT algorithm."
12. A71-21446 (p0210) "EEG analyzer voltage peaks recording on computer, using digital readout for simultaneous initial and terminal stage markings."
13. A71-20816 (p0206) "Sleep period time displacement effect on sleep using EEG recordings."

14. A71-10767 (p0008) "Digital delta filter for quantifying sleep EEG slow wave activity."
15. A71-28380 (p0356) "Natural sleep and wakefulness stages neurophysiology based on bioelectric activity spectral and correlation analyses."
16. A71-31958 (p0409) "Polygraphic sleep recordings automatic analysis, presenting numerical results for rapid and slow eye movements, muscle tone, heart and respiratory rates."
17. A71-33108 (p0417) "Space flight sleep pattern data with EEG, using three descriptors and regression and linear discriminant analysis."
18. N71-11090 (p0051) "Psychological tests for long and short sleepers."
19. N71-24729 (p0390) "Development of apparatus and method for quantitatively measuring brain activity as automatic indication of sleep state and level of consciousness."

The investigator has expressed his thanks for the needed information, and intends to utilize the information where applicable in their program development.

It should also be noted here that NASA STIF search no. T0077, entitled "Computer analysis of EEG," with an original yield of 317 citations, could be made available for duplication and update.

INFORMATION TECHNOLOGY APPLICATION

Problem: UTM-40 DETECTING OXYGEN TOXICITY IN  
THE LUNG

Institution: University of Utah Medical School  
Salt Lake City, Utah

Investigator: Donald Olsen, D.V.M.  
Artificial Organs Research

Acquisition Date: November, 1972 Completion Date: September, 1973

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## PROBLEM OBJECTIVE

Investigator needed latest physiological resource information related to effects of breathing air which is rich in O<sub>2</sub>; as well as a means of detecting these effects, either by methodology or instrumentation.

## BACKGROUND

Test animals (calves and sheep) which are being used as artificial heart transplant recipients are placed in an oxygen-rich breathing environment (approx. 85% by volume) during intensive care recovery. Since the period of IC observation is prolonged beyond normal recovery periods, the animal breathes the O<sub>2</sub> enriched air for long periods of time. Symptoms not unlike those of hyalin membrane disease (reduced ability to transfer O<sub>2</sub> and CO<sub>2</sub> to and from the circulatory system) have been observed, leading toward suspicion that the lung-gas exchange tissues have become altered by over-exposure to oxygen.

## RESOLUTION

Both manual searching and NASA data bank printouts gave reasonably thorough results. NASA STIF search No. T0618 entitled "Oxygen Toxicity" is on record for duplication and update purposes.

The BATeam in this instance was not able to provide the investigator with instrumentation, but the following document from aerospace literature was directly relevant:



1. AD742468 "Calculation of Cumulative Oxygen Toxicity in the Lung" Wright, W. Brandon, from a report of the Navy Experimental Diving Unit, Washington Navy Yard, Washington, D. C.

Official abstract: "The use of elevated oxygen pressures in diving, treatment of decompression sickness, and hyperbaric oxygen therapy exposes the subject to the risk of oxygen toxicity of the lungs. At present no adequate guidelines exist to assist the physician in planning an oxygen exposure which will be safe from this hazard. An extensive multi-year research series recently completed by the University of Pennsylvania, Institute for Environmental Medicine, has allowed the development of calculating an estimated rate of onset and severity of pulmonary oxygen toxicity in man for any oxygen exposure. This report explains that method and provides tables that may be used to rapidly estimate the severity of pulmonary toxicity which may be incurred by any oxygen exposure. Recommendations as to safe limits of oxygen exposures for various procedures are included."

The investigators agreed the method could be applicable, however, the information would have to be correlated to their test animals, since the documentation was specifically for human subjects. A recent fire at the investigator's facility has impaired full evaluation and methodology development.

Most of the work done in determining and measuring the effects of oxygen toxicity in the aerospace industry has been done using rats and humans, and not too many different species in between,....none noted with calves or sheep. However, it is hoped that with the extensive information provided on the effects of oxygen toxicity, from cellular to whole body effects, that the investigator will be able to design his own parameters for the detection of oxygen toxicity in their test subjects. At the present level of funding the project of designing and testing instrumentation for this problem is not possible. And, the feasibility of developing instrumentation is questionable at this point. Most of the effects of the onset of oxygen toxicity can be measured using already existing equipment, (i.e., EEG patterns, blood tests, neuromuscular responses, various respiratory parameters, etc.)

It should be noted in the following partial list of supplied references, how many parameters have been utilized to note the effects of oxygen toxicity:

2. NASA TT F-368, in PROBLEMS OF SPACE BIOLOGY, Vol. 4, "Effect of Certain Physiological Functions of Prolonged Exposure of Animals to Conditions of an Oxygen-Enriched Air Medium," Zhironkin, A.G., et al, p.489 begin, refs.
3. NASA TT F-738, in PROBLEMS OF SPACE BIOLOGY, Vol. 15, "Effect of Hyperoxic Medium on Cells, Tissues and Organs of Experimental Animals," Kotovskiy, Ye. F., et al, p. 145 begin, refs.
4. "Effect of Prolonged Hyperoxia on Red Blood Cell Survival Parameters in the Rat," Leon, Henry A., et al, from Proc. of the 4th Intl. Congress on Hyperbaric Medicine, Igaku Shoin Ltd., Tokyo, 1970.
5. "Ultrastructural Changes in Rat Adrenal Cortex Following Hyperbaric Oxygen," Race, George J., et al, in Proc. of the 4th Intl. Congress of Hyperbaric Medicine, Igaku Shoin Ltd., Tokyo, 1970.
6. "Mechanisms of Oxygen Toxicity at the Cellular Level," Brown, Olen L., AD-742443, Jan. 1972, Contract N00014-67-0287-0002.
7. "Effect of Sleep-Wake Reversal and Sleep Deprivation on the Circadian Rhythm of Oxygen Toxicity Seizure Susceptibility," Dexter, James D., et al, in AEROSPACE MEDICINE, Oct., 1972 p. 1075-1078.
8. A72-31091 (p0344) "Succinate and glutathione as protective agents against chronic effects of hyperbaric oxygen."
9. A72-38704 (p0455) "Neurologic oxygen toxicity - Effects of switch of inert gas and change of pressure."
10. A71-15053 (p0096) "Metal ions effect of oxygen toxicity in rats, noting convulsions and lung edema alleviation through mixed Mg-Mn ion treatment."
11. A71-21938 (p0212) "Central nervous system functions under high oxygen concentrations at normal and elevated pressures."
12. A71-29501 (p0376) "Pulmonary oxygen toxicity development rate and effects on lung volume and alveolar-arterial gas exchange during breathing."

13. A71-41825 (p0578) "EEG study of hyperoxic convulsions in *Macacus nemestrinus* and *Papio* primates, considering preventative effect of Diazepam and derivatives."
14. N71-11101 (p0052) "Mechanisms by which oxygen produces toxic effects on cellular metabolism."
15. N71-11826 (p0068) "Histological aspects and ultra-structure of intoxication in rats by pure oxygen at low pressure."
16. N71-27290 (p0432) "Peroxidase and catalase activity and hyperoxia effects on mice organs, leucocytes, and erythrocytes in pure oxygen under pressure."
17. A70-12243 "Patients with/without coronary heart disease inhaled various gas mixtures to induce arterial hypoxemia and hyperoxia, noting O availability for myocardial metabolism."
18. A70-10863 "Retinal vessels of humans at .11-2.0 atmosphere oxygen partial pressures, noting arterioles and venous dilation response to hypoxia and vasoconstriction response to hyperoxia."
19. A70-14681 "Hyperbaric oxygenation effects on metabolism, comparing protective agents for rats exposed to 5 absolute oxygen pressures."
20. A70-20629 "Protective ability of various compounds against hyperoxia at 5, 7, 9, and 11 atmosphere of pure oxygen."
21. A70-23586 "Hyperbaric oxygen effect on heart muscle contractions in mammals, considering cells enzymatic activity and substrate utilization."
22. A70-23017 "Hyperbaric oxygenation treatment physiology and techniques, discussing limitations of equipment."
23. A70-25674 "Dogs respiratory response to arterial hydrogen ions at different carbon dioxide pressure levels during hypoxia or hyperoxia, discussing acid-base balance effects."
24. A70-43701 "Human and animal tolerances to hyperbaric oxygen, discussing response variation, toxicity modification, etc."
25. A70-40185 "Orthostatic Tolerance Increase in Animals by application of hyperoxic and hypercapnic gas mixtures."

26. A69-18975 "Immunological and histochemical methods for studying mice reactivity after long term exposure to hyperoxic atmosphere."
27. A69-18976 "High Oxygen concentration effect on conditioned reflex and associated EEG responses to light flash in rabbits occurs in well defined sequences."
28. A69-29298 "Pulmonary oxygen toxicity, analyzing reticulin and elastic tissue damage and hyaline membranes by histochemical techniques."
29. A69-39179 "Normobaric oxygen toxicity pathology in baboons and macaca, irus and squirrel monkeys during 14 day exposure."
30. A69-80802 "Pathogenesis and reversibility of pulmonary lesions of oxygen toxicity in monkeys."
31. N69-31438 "Avoidance Reactions of man and animals to hypoxic environments."

INFORMATION TECHNOLOGY APPLICATION

Problem: UTM-44 DETECTION/MEASUREMENT OF  
MICROBUBBLES OR MICROTHROMBI  
IN THE BLOOD

Institution: University of Utah Research Foundation  
Salt Lake City, Utah

Investigator: Norman deGroot  
Artificial Heart Test Facility

Acquisition Date: November, 1972 Completion Date: September, 1973

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## PROBLEM OBJECTIVE

Investigators needed equipment or technique for detecting and measuring small gas bubbles and blood clots in the circulation.

## BACKGROUND

This facility tests and evaluates extra-corporeal circulation devices. Among those common effects from "heart-lung" type devices is the occurrence of micro bubbles and micro blood clots in the circulating blood. The evaluation could be greatly assisted if the presence of these foreign substances could be quantified.

The equipment associated with any such measurement should be non-invasive so as not to cause blood trauma in itself. This facility has mechanical and electronic fabrication capability on site, as well as access to printed circuit board and microcircuit facilities and technicians. It may be desirable to eventually consider connections to an in-house physiological data gathering system.

## RESOLUTION AND EVALUATION

After receipt of an extensive supply of NASA documents and references, the investigators have stated that they have gathered more than sufficient information to begin design work on special equipment. For purposes of research priority they did not feel obligated to provide us with their full design intentions, but were appreciative of NASA's help in gathering needed information.

It should be noted here that although the use of ultrasonics for detection of embolisms in the blood is not that new, nor is it strictly of NASA origin, NASA technology has been utilized to improve or handle special applications of ultrasonic blood flowmeters.

Specifically, the NASA BATEam at Research Triangle Institute in North Carolina worked with Mr. Sal Rositano at NASA/Ames to utilize their ultrasonic blood flowmeter using the Doppler technique (now commercially available through L&M Electronics, Inc. of Daley City, California) for the Department of Anesthesiology at the Ochsner Clinic in New Orleans. In this unit, the flow is measured by utilizing the change in frequency of an ultrasonic signal that is associated with the velocity of the liquid through which the sound is propagating. Embolisms traveling with the flowing blood generate a loud return signal, which in the case of a flow measurement would be an error signal, but in the case of embolism detection, would be precisely the needed signal. The RTI BATEam was able to help their investigator modify his existing system to incorporate a membrane oxygenator from his previously used bubble oxygenator. The combination of using the membrane oxygenator with the NASA developed ultrasonic doppler flowmeter enabled the investigator to detect the existance of embolisms.

With reference to the above technique, we cite the following article:

"Ultrasonics Imaging of In Vivo Bubbles in Decompression Sickness," Rubissow and Mackay, in ULTRASONICS, Oct., 1971, p. 225.

Other references that our investigator found of particular interest follow:

2. A69-43414, "Decompression Disease"
3. A69-38915, "Detection of gas emboli associated with decompression using the doppler flowmeter."
4. A69-38914, "Experiments on decompression bubbles in the circulation using ultrasonic and electromagnetic flowmeters."
5. N68-13107, "Etiology of decompression sickness--characteristics of bubble formation in vivo."
6. A71-40342, "Pulmonary Capacity for dissipation of venous gas emboli."
7. A71-12418, "The search for an anti-thrombotic agent."

8. A70-43700, "Decompression Sickness and the Cardiovascular System"
9. A70-32312, "Experimental study of air bubbles in a simulated cardiopulmonary bypass system with flow constriction."
10. X68-15325, "Design of Devices for Optimum Blood Flow."

INFORMATION TECHNOLOGY APPLICATION

Problem: VAL-3 COMPUTER APPLICATIONS IN HOSPITALS  
-A PRACTICAL CRITERIA COLLATION

Institution: Veterans Administration Hospital  
Little Rock, Arkansas

Investigator: Jack B. Johnson  
Medicine and Surgery

Acquisition Date: April, 1973 Completion Date: June, 1973

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#### PROBLEM OBJECTIVE

The investigator asked for NASA assistance in gathering up-to-date information concerning computer applications in hospital systems.

#### BACKGROUND

Hopefully, medical personnel are awakening to the reality of both the advantages and disadvantages of computers in the hospital. However, because the computer represents an area of many misunderstandings, large hospital administrations need to be made aware of the potential applications and cost containment when computers are properly installed, used, and understood.

#### RESOLUTION

Of prime importance, the NASA STIF computer search no. T730 gave us reference to 686 documents that spoke of computer techniques and programs and their use in basic research and clinical usage, with emphasis on hospital applications. The search is on record and would be available for duplication and update.

Of particular interest are the following documents made available to the problem originator:

SELECTING A COMPUTER SYSTEM FOR THE CLINICAL  
LABORATORY, Marion J. Ball, Charles C. Thomas,  
Publisher, Springfield, Illinois.



AD-677593 "Automation for the Hospital of Tomorrow,"  
Oct., 1968.

PB-195 629, "The use of computers in hospitals," by  
Herner and Company, Washington, D.C., Nov., 1970, for  
the National Center for Health Services Research and  
Development, Contract No. PH 110-233.

Official abstract: "This, the third and major report  
returned under Contract PH 110-233, provides a general  
analysis of the returns from a detailed questionnaire  
on 'The use of Computers in Hospitals and other Medical  
Facilities.' The questionnaire was mailed to the  
administrators of 2,431 hospitals in May, 1968. The  
analysis which is based on returns from 1,200 hospitals,  
presents findings on each hospital application in terms  
of number of times cited and percentage of respondent  
citing. Principal applications reviewed are administra-  
tive and financial; operational procedures (cost analysis,  
inventory); medical and medical research; and applications  
involving remote terminals. The report concludes with  
general reviews of principal applications. The appendices  
are: name and mailing address of respondents; question-  
naire identification by State and HEW Region; and types  
of computers used."

INFORMATION TECHNOLOGY APPLICATION

Problem: WMC-1 PLETHYSMOGRAPHIC DATA INTER-  
FACING SYSTEM

Institution: University of Wisconsin Medical College  
Milwaukee, Wisconsin

Investigator: J.J. Smith, M.D., Ph.D.

Acquisition Date: October, 1972 Completion Date: June, 1973

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## PROBLEM OBJECTIVE

Investigators desired an interface between the Kubicek Impedance Plethysmographic output and computer.

## BACKGROUND

In their facility, plethysmographic data was being hand analyzed utilizing the Gerber method. Investigators wished to automate data analysis to reduce time spent by professional medical personnel, and simultaneously reduce overall cost of operation. The interface was desired for the Kubicek Impedance Plethysmograph (Minnesota Impedance Plethysmograph)

## RESOLUTION

NASA STIF search no. T614 gave us 202 references on the subject, and this is available on record for duplication and update.

Investigators had expressed interest in the NASA developed IMBLMS system developed by Dr. William Kubicek. Through the efforts of personnel at Johnson Space Center, the investigators were provided with the complete computer program from the IMBLMS program:

"Biomedical Computer Applications Program--Software Description," compiled by Edward Kresch, Ph.D., from a report on contract NASW-1630 by General Electric.

The investigators have reported that this information has indeed been very helpful and has enabled them to stay abreast of latest possible technical developments. Due to other pressing projects, implementation of the computer software has been suspended until a particular grant request comes through at which time they will of course continue with the supplied technology and re-establish team contact.

## 2.2 Potential Technology Applications

Below is a list of potential technology applications as they stand at contract termination. On the following pages are summaries for these potential applications.

<u>No.</u>	<u>Problem Title</u>	<u>Date Opened</u>
AEB-5	Motion Sensor to Provide Biofeedback to Blind Persons Unaware of Involuntary Movements	01-73
AVA-2	Carotid Artery Pressure Waveform Measurement	10-70
CHS-10	Hearing Aid Malfunction Alarm System	01-71
CRH-5	Improved Clamp for Urine Collection Device	12-72
CRH-7	Joy-Stick Control for Automobile	03-73
GLM-35	Beta Radiation Catheter Probe	09-70
MDA-1	Radiation Resistant Tilt Table for Use in Radiotherapy	08-72
MSC-1	Portable Scalp Cooling Device	12-72
OVA-2	Measurement of Lung Compliance	07-70
SDU-1	Complete Portable System for Acquiring and Analyzing Audio Evoked Responses	04-73
SWC-2	Evoked Cortical Audiometry Measurements	10-70
TCB-20	Device to Enable Blind Diabetics to Self-Assess Urinalysis Tests	05-73
TCD-4	Noise Activated Flasher Warning Device for Deaf Driver	03-71
TTU-3	Rate Monitor for Self-Injurious Behavior	01-73
TTU-4	Nocturnal Activity Monitor	01-73
TTU-5	Control of High Blood Pressure by Biofeedback Techniques	05-73
UAD-7	Telemetry of Oral pH for Determination of Linkage to Cavity Formation	09-71
UAM-14	Self-Propelled Metabolic Analyzer Cart	01-72
UTM-38	Improved Urethral Valve for Nonsurgical Implantation	03-72
UTM-39	Multi-Channeled Hypothermia Blanket for Heart Surgery	11-72

POTENTIAL TECHNOLOGY APPLICATION

Problem: AEB-5 MOTION SENSOR TO PROVIDE BIOFEEDBACK  
TO BLIND PERSONS UNAWARE OF INVOLUNTARY  
MOVEMENTS

Institution: Arkansas Enterprises for the Blind  
Little Rock, Arkansas

Investigator: Elmo Knoch  
Director of Training

Acquisition  
Date: January, 1973

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#### PROBLEM OBJECTIVE

Investigators have long sought an effective, inexpensive, reliable means of developing a motion sensor with auditory or tactile feedback for blind persons who unknowingly rock back and forth.

#### BACKGROUND AND APPROACH

In a report to the DE5 Medical Applications Officer, William Bush, Chief, Operational Systems & Planning Branch, has presented the following tentative implementation plan:

The investigator indicated that he is not aware of any studies that have provided accurate measurements of either rocking motions or frequency of rock. Literature on the subject has been limited to observations and theory of cause. From his experience with blind people, the investigator stated that the rocking motion is generally 6 inches with more severe cases exhibiting movements of 3-4 foot arcs. The observed frequency is in the 60-70 CPM range. The condition of the rock has been explained as a scanning for sound or a form of autoerotism.

The direction of rock varies, but each individual follows a pattern that is unique to himself in a single axis.

Although this motion is not a safety hazard, the blind person when traveling tends to become disoriented if such involuntary motion should start. It also becomes a disruption factor in work situations where blind persons are in contact with normal sighted individuals.

A blind person will respond and cease the motion when made aware of his action. For this reason, the investigator suggested a sensor that would respond to the motion and provide some sort of feedback. If successful, the unit could be utilized with blind children. (Or it is even feasible it could help the elderly, or persons with nervous disorders).

It is felt that the same general technique that is utilized with the "M133, Sleep Monitoring Experiment," (SKYLAB) sleep cap can be applied here. In this experiment, a small accelerometer with a sensitive preamp is used to detect unwanted head motions. Endevco, the developer of this unit was contacted. The company indicated they have several units that could detect the types of motion at the frequencies we are interested in. The price range is approximately \$500, and they will follow up with the technical data sheets. From a cursory review it is recommended that this be explored. Some prerequisites that will require study are as follows:

1. Accurate measurements of motion and frequencies.
2. Location of sensor, review of responses for range of individuals.
3. Method of distinguishing between normal motion and rock if response proves to be similar.
4. Type of feedback-audible, tactile, etc.
5. Psychological study to determine any detrimental effects of rock elimination. Does rock fulfill any useful function?
6. Develop method of providing continuous monitoring of subject.

The investigator has indicated there would be no objection to working with some of the blind at the institute. He also has available or can readily obtain most of the standard test equipment. This should aid in providing solutions to items one and two.

Logic to differentiate between rock and other motions (item three), if applicable, would have to be developed after some detailed measurements were accomplished.

Items four and five can be worked in conjunction with the Psychology Department of the University of Arkansas (located several blocks from the school). Dr. J. Barnes, a motivational specialist, and Dr. Wood, Chairman of the Psychology Department, have indicated a willingness to support any efforts in this area.

The investigator's facility has a PDP-8F computer and has had several communication frequencies recently assigned to them. With use of a transmitter and receiver the computer could be keyed to provide record keeping on the subject (item six). The school is presently attempting to obtain such a transmitter and receiver from the Air Force. This type of effort could be a follow-on and/or additional associated activity.

POTENTIAL TECHNOLOGY APPLICATION

Problem: AVA-2 CAROTID ARTERY PRESSURE WAVEFORM  
MEASUREMENT

Institution: Veterans Administration Hospital  
Birmingham, Alabama

Investigator: William Bancroft, Jr.  
Cardiology Research

Acquisition

Date: October, 1970

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PROBLEM OBJECTIVE:

Investigator requested NASA technological help in identifying or developing a flexible pressure transducer to noninvasively measure carotid artery pressure in humans.

BACKGROUND

This facility in the past had been using a glycerine-filled transducer to monitor the pressure waveform of the carotid artery in their patients. They use the acquired data to check circulation and correlate these findings with normal sphygmomanometer blood pressure readings taken from the arm. These glycerine-filled transducers are no longer being manufactured, and the investigators wished to find a suitable, improved substitute. The unit should be comfortable to wear, and should be linear from DC to 10 Hz.

POTENTIAL APPROACH

Through the efforts of Wayne Chen, Technology Utilization Office, NASA/Goddard, the BATEam was made aware of Goddard's development of an improved arterial pulse wave pressure transducer...noninvasive and economical. Recently, a NASA Tech Brief has appeared on the device, and it is included after this summary for documentation. (B73-10046).

Goddard has fabricated several of the units, and at last contact was working on evaluation studies with the Veterans Administration Hospital in Washington, D. C. Our investigator has been provided with essential information on the unit and still desires to pursue a personal evaluation.

In addition to the new transducer, the BATEam is interested in applying an idea developed by G. W. Hoffler, M.D., Chief

of the Cardiovascular Branch at Johnson Space Center. In their work, they perform carotid artery pressure measurements requiring long-term application of the measuring device (minimum wearing time of 25 minutes). Their chief concern was comfort, and for same they have come up with the idea of utilizing a "neckband" made of the same material (lead lined) used to fabricate aprons used in X-ray labs. The material is heavy enough to "lay" across the neck without having to be secured completely around the neck. Depending upon the size of the individual being measured, they put "caps" of either lead or stainless steel over the transducer (which fits through a hole cut in the apron material) to achieve the proper skin contact.

The BATeam would like to pursue the implementation of both the Goddard unit and Dr. Hoffler's contact method for clinical feasibility.

From the patent application for the arterial pulse wave transducer we would like to include the official abstract:

"A novel arterial pulse wave pressure transducer is disclosed, the transducer, comprising a fluid-filled cavity having a flexible membrane member disposed over the cavity and adapted to be placed on the skin over an artery. An arterial pulse wave creates pressure pulses in the fluid which are transduced by a pressure-sensitive transistor disposed in direct contact with the fluid into an electric signal. The electrical signal is representative of the pulse waves and can be recorded so as to monitor changes in the elasticity of the arterial walls, and the like."



# NASA TECH BRIEF

## Goddard Space Flight Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### An Economical Arterial-Pulse-Wave Transducer

#### The problem:

Arteriosclerosis is one of the leading causes of illness and death in human beings. One important method in detection of this disease involves the measurement of arterial pulses by use of transducers which convert these pulses into electronic signals. These signals are recorded and interpreted by physicians who then establish the presence and severity of the disease. Depending on design, transducers may be applied internally or externally. The former is painful because it requires an insertion of a needle into an arterial wall, and the latter requires expensive components to reproduce accurate readings from skin area above the artery.

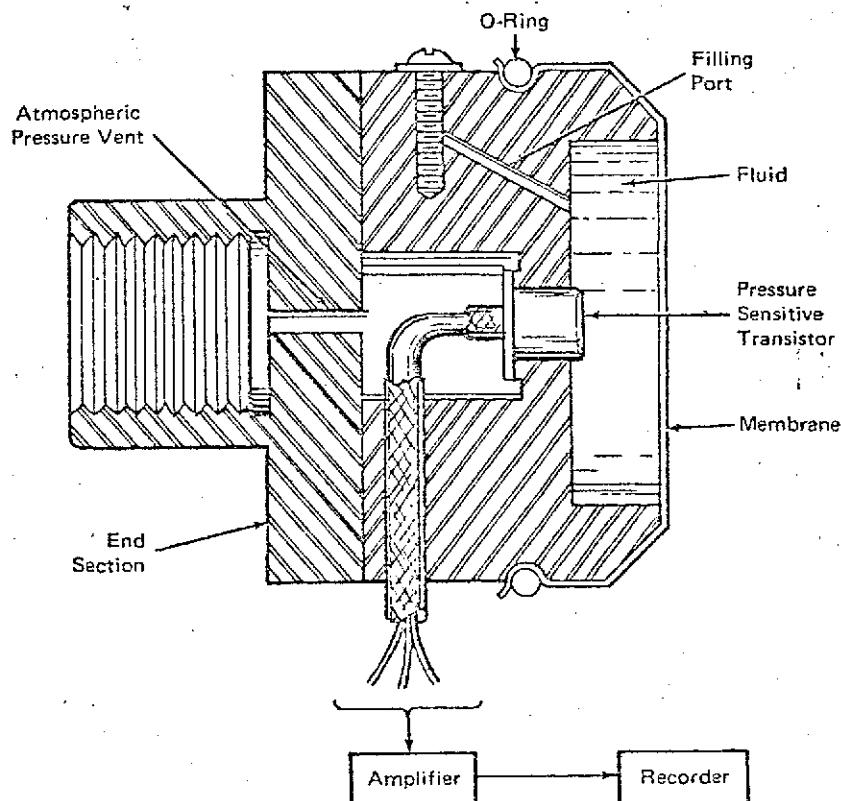
#### The solution:

An inexpensive arterial-pulse-wave transducer has been developed which can record arterial pulses externally.

#### How it's done:

The transducer (see figure) uses a thin plastic membrane which is fluid coupled to a pressure sensitive transistor. The transistor is connected to an amplifier which, in turn, is connected to a recorder.

In use, the plastic membrane side is placed in contact with the human skin just above the artery that is to be recorded. Pulses produced by this artery will vibrate the



(continued overleaf)

membrane. This vibration is transmitted through a suitable liquid to a pressure sensitive transistor. The transistor is specially designed so that its casing is mechanically coupled to an internal p-n junction. Vibration of the casing causes variations in the transistor current gain which correspond to arterial pulses. These signals are then transmitted to an amplifier and recorded for the physician's evaluation.

The entire transducer is enclosed in a sturdy plastic housing, the end section of which is threaded to accept a suitable holder. The end section also contains a pressure relief vent to allow the transistor to sense only pressure levels that are greater than atmospheric.

**Note:**

Requests for further information may be directed to:

Technology Utilization Officer  
Goddard Space Flight Center  
Code 207.1  
Greenbelt, Maryland 20771  
Reference: TSP73-10046

**Patent status:**

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel  
Goddard Space Flight Center  
Code 204  
Greenbelt, Maryland 20771

Source: Chung Kim, Donald Gorelick,  
and Wayne Chen  
Goddard Space Flight Center  
(GSC-11531)

## POTENTIAL TECHNOLOGY APPLICATION

Problem: CHS-10 HEARING AID MALFUNCTION ALARM SYSTEM

Institution: Callier Hearing and Speech Center  
Dallas, Texas

Investigator: Frank Powell  
Aram Glorig, M.D.

Acquisition  
Date: January, 1971

### ----- PROBLEM OBJECTIVE

A miniature alarm system is needed to give warning of any malfunctioning within the hearing aid of deaf or deaf-blind children.

### BACKGROUND

The extremely fragile nature of the hearing aids for the very young deaf or deaf-blind children, makes them subject to malfunction due to the hard usage factor. These children cannot readily communicate and their habilitation is primarily based upon retention and amplification of available residual sensory physiology that is present. The hearing aids need to work for this habilitation to be most effective. A schedule of screening and rather crude testing is the only apparent solution presently available. Investigators suggested that the device should either sound or flash an alarm to alert the therapist of any malfunction in the amplification, the breakage of lead wire, or if possible, also the distortion in quality of sound. The system should be miniature to be accomodating to the size and use of present hearing aid configurations and wearing constraints. It cannot be stressed enough that in the learning environment of these children, it is essential that their hearing aid devices must be in working condition, or what little contact they have with their environment (especially in the case of deaf-blind children) is literally cut off from the outside world, a psychologically devastating event in habilitation.

### POTENTIAL APPROACH

The problem is currently under feasibility study at Johnson Space Center under the direction of William Bush, Chief, Operational Systems & Planning Branch (DE5). It should be noted that NASA does not intend to develop a "new" hearing aid.

But it would be appropriate that NASA could aid in the development of these sensitive malfunctioning systems to solve a very important rehabilitation problem.

Personnel at Johnson Space Center are in possession of a hearing aid of the type frequently in use at the investigator's facility. It is more than feasible that NASA circuitry technology can be applied if we are allowed to keep the problem solution implementation under consideration.

Depending upon the nature of the technique, should it be developed, the technology could be applied to other areas of rehabilitation, especially in patient monitoring, where malfunction warnings would be essential.

## POTENTIAL TECHNOLOGY APPLICATION

Problem: CRH-5 IMPROVED CLAMP FOR URINE COLLECTION DEVICES

Institution: Craig Rehabilitation Hospital  
Englewood, Colorado

Investigator: Nena Robbins  
Occupational Therapist

Acquisition Date: December, 1972

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### PROBLEM OBJECTIVE

Investigators are seeking a positive closing, easy opening, miniaturized tubing occlusive clamp to be used inline before the urine collection bag during emptying of the bag.

### BACKGROUND

Paraplegics suffering incontinence wear a urine collection bag strapped to the inside of the leg, usually below the knee. Existing clamp devices are bulky and abrasive and tend to leak during the emptying of the bag.

Since the device is commonly worn under trouser legs it should be near flat for minimal bulge and non-abrasive for tissue comfort.

### POTENTIAL APPROACH

The BATEam identified a NASA Tech Brief, B72-10687, "A Shut-Off Valve for Flexible Tubing," that the team would like to explore, with modifications, as an approach to the problem. A copy of the tech brief follows this report, and with a description and sketch, is self-explanatory.

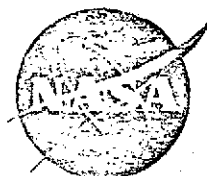
Another suggestion has come from Cary R. Sptizer at Langley Research Center. His preliminary sketch for an "In-Line Urine Bag Valve" follows this summary.

John R. Johnson, also of Langley Research Center, has submitted a preliminary idea for a solution approach.

The BATEam feels implementation of these ideas to final solution should be considered and would incur rather minimal engineering costs.

# NASA TECH BRIEF

## Marshall Space Flight Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

### A Shut-Off Valve for Flexible Tubing

#### The problem:

Shut-off valves used with flexible tubing must, in many cases, be "normally closed" and provide a tight seal. (For example, the design of this valve was motivated by the need for such a clamp for a urine hose.)

#### The solution:

A simple, reliable, light weight valve was designed to be hand operated and to provide positive sealing in its normally closed position.

#### How it's done:

The valve as shown in Figure 1 is in the normally closed position. The two leaf springs force the jaws closed on the flexible tubing and shut off the flow through the hose.

Figure 2 shows the valve in the open position. When the lever is pressed down, the leaf springs and jaws are forced apart to allow liquid flow through the tube.

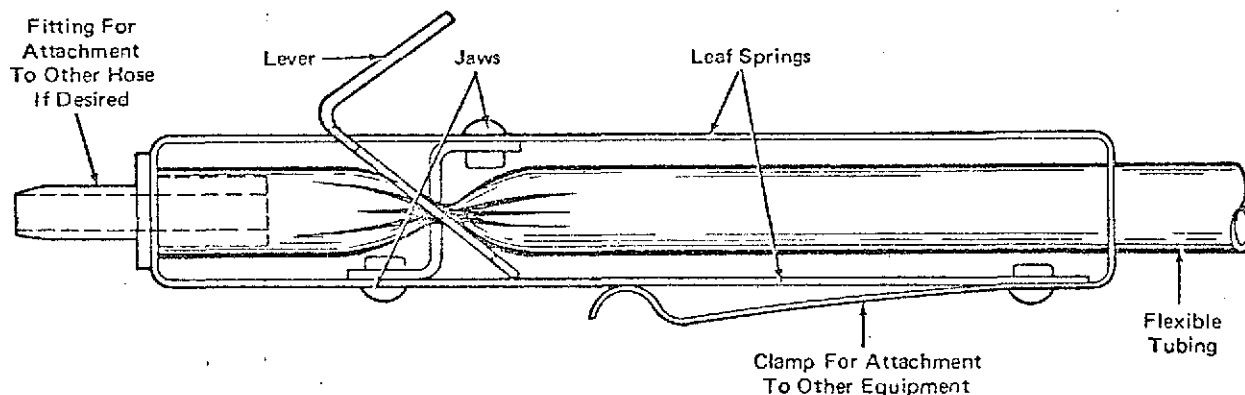


Figure 1. Valve in Normally Closed Position

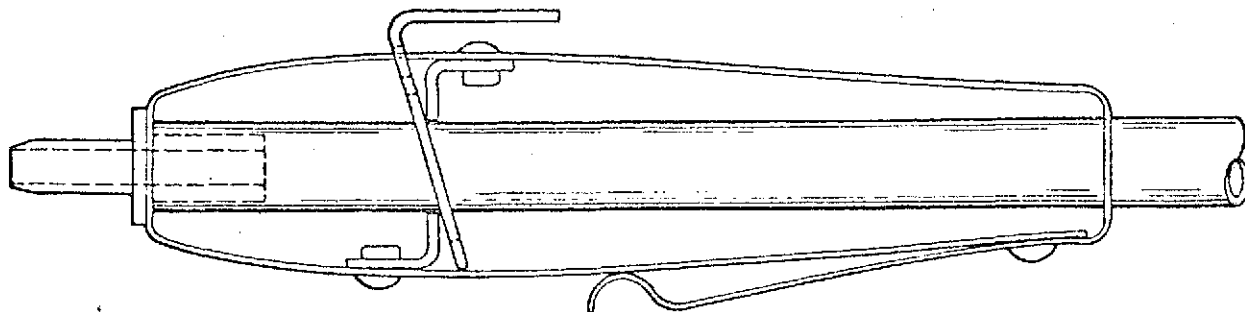


Figure 2. Valve in Open Position

(continued overleaf)

**Notes:**

1. Information concerning this innovation may be of interest to manufacturers of hose clamps.
2. No further documentation is available. Specific questions, however, may be directed to:  
Technology Utilization Officer  
Marshall Space Flight Center  
Code A&PS-TU  
Marshall Space Flight Center, Alabama 35812  
Reference: B72-10687

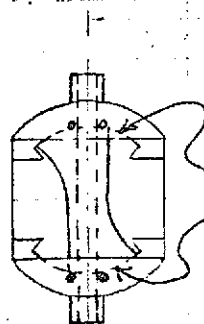
**Patent status:**

NASA has decided not to apply for a patent.

Source: W. W. Reyburn of  
McDonnell Douglas Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-21731)

# In-Line Urine Bag Valve (TUO Ref: CRH-5)

Material: Cast nylon Scale: 1:1



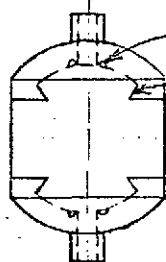
Assembly Top View  
(closed)



Ass'y Side View  
(closed)



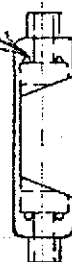
Ass'y End View  
(closed)



Housing Top View

O-ring groove  
(2 places) Note 1

Rotor stop  
(4 places)



Housing Side View

Overhang  
retains rotor.  
(2 places)  
Flex housing to  
snap rotor into  
place.



Housing End View



Rotor Top View



Rotor Side View



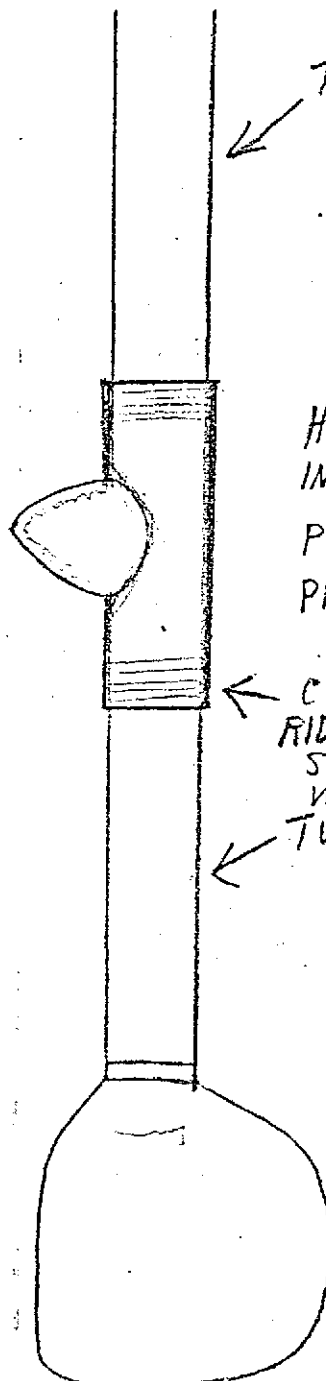
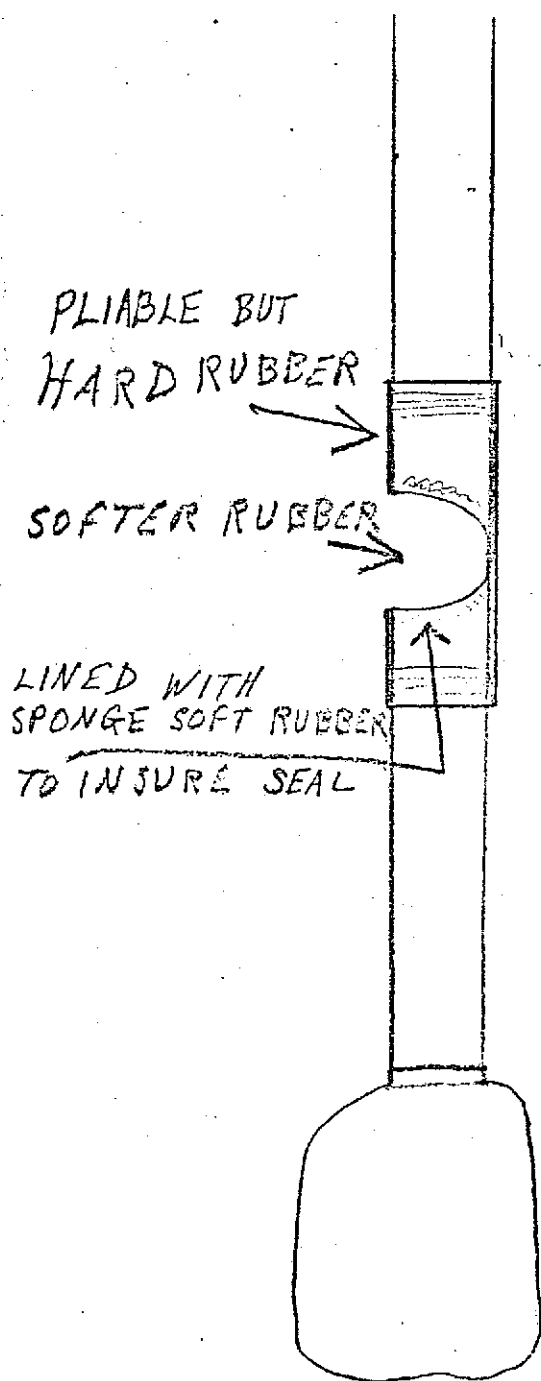
Rotor End View

Note 1: O-ring may be eliminated if housing is rigid enough and tolerances are tight enough to prevent leakage.

Cary R. Spitzer, VPO  
Feb. 5, 1973 x3081



TO CATHETER  
OR FITTING



BASIC IDEA

HARDER RUBBER WITH ROUNDED  
INDENTATION (LIKE OIL CAN)  
PRESS TO CUT OFF  
PRESS OUT TO OPEN

← COULD BE MANUFACTURED W/  
RIDGES SO TUBE COULD BE  
STRECHED OVER FOR CHANGIN.  
WHEN WORN OUT.

← TUBE

JOHN R. JOHNSON  
MS 196 Phone 2016

POTENTIAL TECHNOLOGY APPLICATION

Problem: CRH-7 JOY-STICK CONTROL FOR AUTOMOBILE  
Institution: Craig Rehabilitation Hospital  
Investigator: Tom Wertz  
Acquisition  
Date: March, 1973

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## PROBLEM OBJECTIVE

Although some commercial aids for handicapped drivers do exist, investigators wanted to explore the possibility of implementing NASA technology for a joy-stick type of control console for use in standard, power-equipped automobile that could be easily installed and disengaged for "normal" drivers.

## BACKGROUND AND APPROACH

Many physically handicapped persons can drive automobiles fitted with existing types of adaptive controls. Many others (such as paraplegics with additional complications, elderly, and heart patients, mid-to-low-level quadriplegics, polio victims, and others) are not strong enough. Handicapped people have an intense desire for independence, a desire which is squelched by their inability to transport themselves around town and across country. A lot of talented and capable people are being kept out of productivity by their lack of mobility.

A possible aid to independent automobile travel for the handicapped has been developed for the Apollo program. The joy-stick control device for the Lunar Rover Vehicle appears to offer one-hand control capabilities to the automobile driver. By manipulating the single control lever, the Apollo astronauts were able to control the LRV in direction, speed, and braking--replacing the steering wheel, accelerator and brake pedals, and shifting lever.

The joy-stick control concept was demonstrated in the late 50's by General Motors Research Lab with the highly experimental Firebird III. A similar concept was adapted to a standard 1967 automobile by graduate students at the University of Illinois, though theirs was a rather crude network. That the LRV type control system could be easily and inexpensively attached to a standard automobile remains to be demonstrated.

Under the auspices of the BATEam program, in cooperation with SwRI experts and selected outside consultants, we would like to conduct a feasibility study to do the following:

1. Assess Driver Ability

Determine muscular function levels of standard physical disability categories as they relate to ability to operate a joy-stick control device. Some information is available in the literature, since joy-stick controls are used on electric wheelchairs. It may also be useful to use the Complex Coordinator Device for assessment of eye-to-hand coordination and muscular control sensitivity. An attempt would be made to obtain a training version of the LRV control for use by handicapped test subjects. Physiatrists will be consulted for other suitable means for evaluation.

2. Survey Interface Mechanisms

Study the control output functions of the LRV joy-stick mechanism and select means of interfacing to the standard automobile. Selection of suitable effector components for steering, carburetor, transmission, and brake controls will be governed by reliability, ease of installation, and low cost. A separate, but parallel study will consider necessary accessories to aid vehicle entry and restraint of the handicapped driver, as well as control of automobile light, horn, turn indicators, and air conditioner switches.

3. Synthesis and Conclusions

From the assessment of driver ability and design and development options for the control device, recommendations will be formulated for follow-on effort. Based on reports from funded programs in rehabilitation research and from inquiries from interested state agencies, it appears that there could be cooperative support available from such sources as Social and Rehabilitation Services (HEW), the automobile industry, American Automobile Association, insurance companies, as well as private foundations.

POTENTIAL TECHNOLOGY APPLICATION

Problem: GLM-35 BETA RADIATION CATHETER PROBE

Institution: University of Texas Medical Branch  
Galveston, Texas

Investigator: Hermann Rudenberg, Ph.D. (coordinator)

Acquisition  
Date: September, 1970

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## PROBLEM HISTORY

Although the original problem centered around one objective, several are now documented. Briefly, the implementation is comprised of the development of a catheter tip, solid state radiation detector used to measure beta radiation levels in blood. Three current needs for the device can be stated as follows:

1. TO MONITOR CEREBRAL BLOOD FLOW IN HEAD-INJURY PATIENTS - A device was needed which would permit assessment of (1) the effect of various pharmacologic agents upon cerebral blood flow, and (2) progress towards recovery as an accompaniment to various therapeutic regimens. The only practical way in which physicians can presently accomplish this involves administration of a radioactive gas (Krypton 85) and then over a protracted period withdraw blood samples by (1) piercing the carotid artery (to determine Krypton 85 concentration of blood entering the brain) and (2) piercing the jugular vein (to determine Krypton 85 concentration of blood leaving the brain.) Appropriate comparisons of the resulting data--over extended periods of time---allow the physician to monitor, in a rather primitive fashion, cerebral blood flow. The repeated piercing of the veins and arteries subjects the patients to undue amounts of needless suffering, increases the risk of infection, and requires an inordinate amount of time for setting up, taking the sample and analyzing the samples repeatedly.

2. CHRONIC INTRA-ARTERIAL FIBRIN DEPOSITION - Many believe that coronary and other atheromatous arterial narrowing, by far this country's most important cause of death, results from chronic intra-arterial fibrin deposition. This is still a controversial etiological hypothesis. The beta radiation probe could help in establishing or ruling out this idea. Specifically, it is desired to administer  $^{125}\text{I}$  tagged fibrinogen followed by catheter-tip transluminal measurement of local radiation. In this way, it is believed that even minute amounts of fibrin incorporated into growing early lesions could be detected and of course localized at the affected arterial wall site. Secondary thrombus could be easily localized, in itself a significant clinical contribution.
3. BASIC CARDIOVASCULAR RESEARCH - Other investigators are desirous of using the beta radiation catheter device to detect an iodine isotope tagged digitalis in the myocardium.
4. DETECTION OF EYE TUMORS - Investigators have been administering an isotope which has a proclivity for concentrating in abnormal eye tissue and then, using a rather bulky and inaccurate geiger counter, they wanted to insert the device behind the eyeball to help locate the presence of eye tumors with greater accuracy. Understandably, the beta radiation probe would be more efficient.

To recap the history of the GLM-35 probe development, the BATEam originally located a NASA Tech Brief B66-10252 that described a reliable, miniaturized solid state radiation detector suitable for IN VIVO use which, by incorporation of a preamplifier immediately behind the detector, could solve several problems. The radiation detector and preamplifier would be installed in a #7 French double lumen catheter, thus enabling one or more probes to be inserted into needed areas and left in place for extended periods. The output of the detector can be fed into the appropriate accessory instrumentation (such as a multichannel analyzer) to provide virtually instantaneous information, especially in monitoring blood flow.

The SwRI BATEam has obtained several of the solid state radiation devices and perfected the required preamplifier. And Between the BATEam and NASA help at Langley Research Center miniaturized the preamplifier on a thin film chip for installation behind the detector, which was essential for low noise and adequate sensitivity.

Assistance has been solicited from specialists at The University of Missouri, working under NASA contract to help the team develop an improved protective coating for the probe detector element that would not sacrifice sensitivity.

Pending additional funding, it is essential for final technology application efforts of the GLM-35 beta radiation detector probe, that an extensive test and fabrication protocol be established so that a high yield of functional devices can be achieved. It will be necessary to provide a shielded test facility with a beta reference. Provisions would be made to test the miniature elements upon receipt, to test the transducer assembly at any stage of fabrication and to perform periodic tests on completed transducer units. This test unit will be portable so that it can be loaned to and perhaps duplicated by researchers who intend to use the transducers. The preamplifier circuit design will be verified further and a package of smaller diameter will be fabricated if possible.

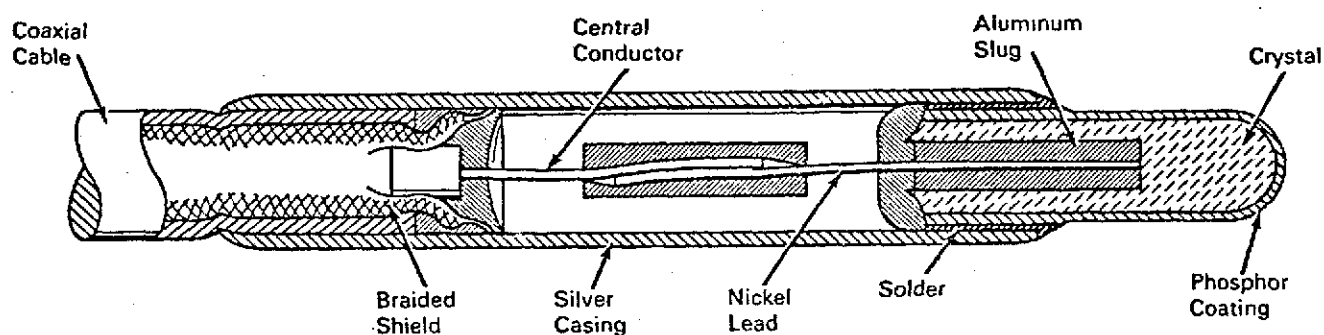
NASA tie-in information, radiation probe sketches and circuitry and a brief description of the device follow this summary.

# NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Semiconductor Forms Biomedical Radiation Probe



### The problem:

To produce a reliable miniaturized radiation dosimeter for biomedical application in vivo. External dosimeters do not accurately indicate dose level within the irradiated cells because the greater radiation damage is caused by photoelectrons and knock-on protons. Proposed chemical dosimeters for in vivo applications are only partially satisfactory since they will not indicate rate of absorption or number of particles absorbed.

### The solution:

A semiconductor radiation detector in the form of a slender probe that is easily inserted into body tissue. The probe has a signal-to-noise ratio that is acceptable to recording equipment and it provides realistic measurements of the spatial and energy distributions of radiant electrons and protons.

### How it's done:

The probe detecting element is a semiconductor diode of the junction type fabricated from a high resistivity silicon crystal doped with P-type impurities.

The probe has the general shape of a clinical thermometer with the detector in the form of the mercury reservoir. The P-N type junction at the crystal is formed by the diffusion of phosphorus over the crystal surface. A silver casing holds the phosphorus coated crystal and connects with the ground lead (braided shield) of a miniature coaxial cable whose central conductor contacts a nickel lead from an aluminum slug in the body of the crystal. The silver casing is tin soldered to the phosphorus coated crystal by means of a nickel plate on the phosphorus and the other end is hermetically sealed to the coaxial cable external insulation that is impervious to body fluids.

In operation, reverse bias is applied to the P-N junction, and radiation penetrating the junction is converted to voltage pulses that are conducted to recording equipment via the coaxial cable.

### Notes:

1. This device would be useful in evaluating blood flow problems by insertion into veins and arteries to measure the spatial and energy distributions of radioactive tracers.

(continued overleaf)

2. Inquiries concerning this invention may be directed to:

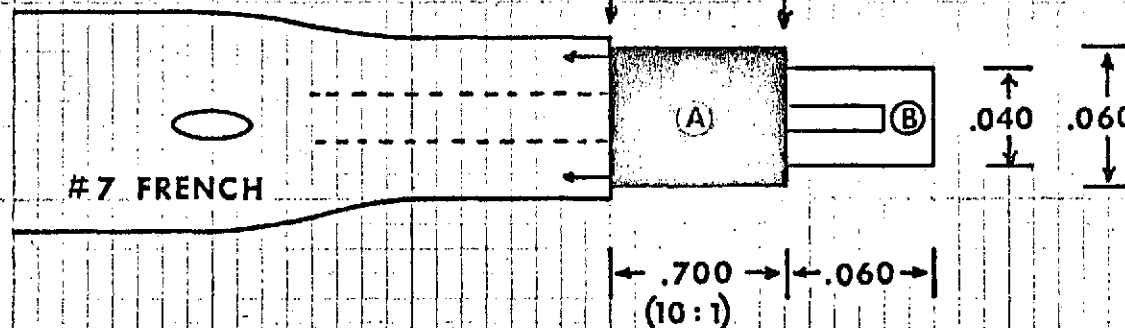
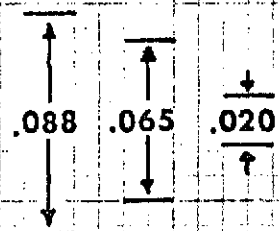
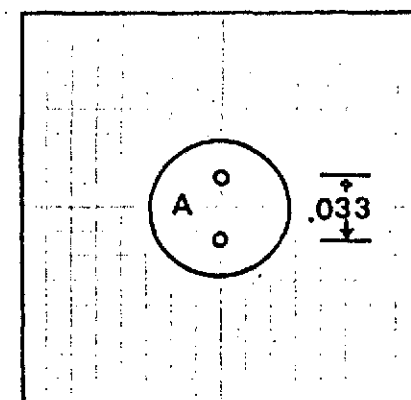
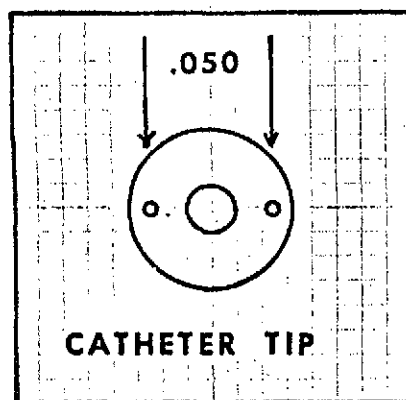
Technology Utilization Officer  
Manned Spacecraft Center  
Houston, Texas 77058  
Reference: B66-10252

**Patent status:**

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: Fred P. Burns and Josef E. Friedericks  
of Solid State Radiation Incorporated  
under contract to  
Manned Spacecraft Center  
(MSC-320)

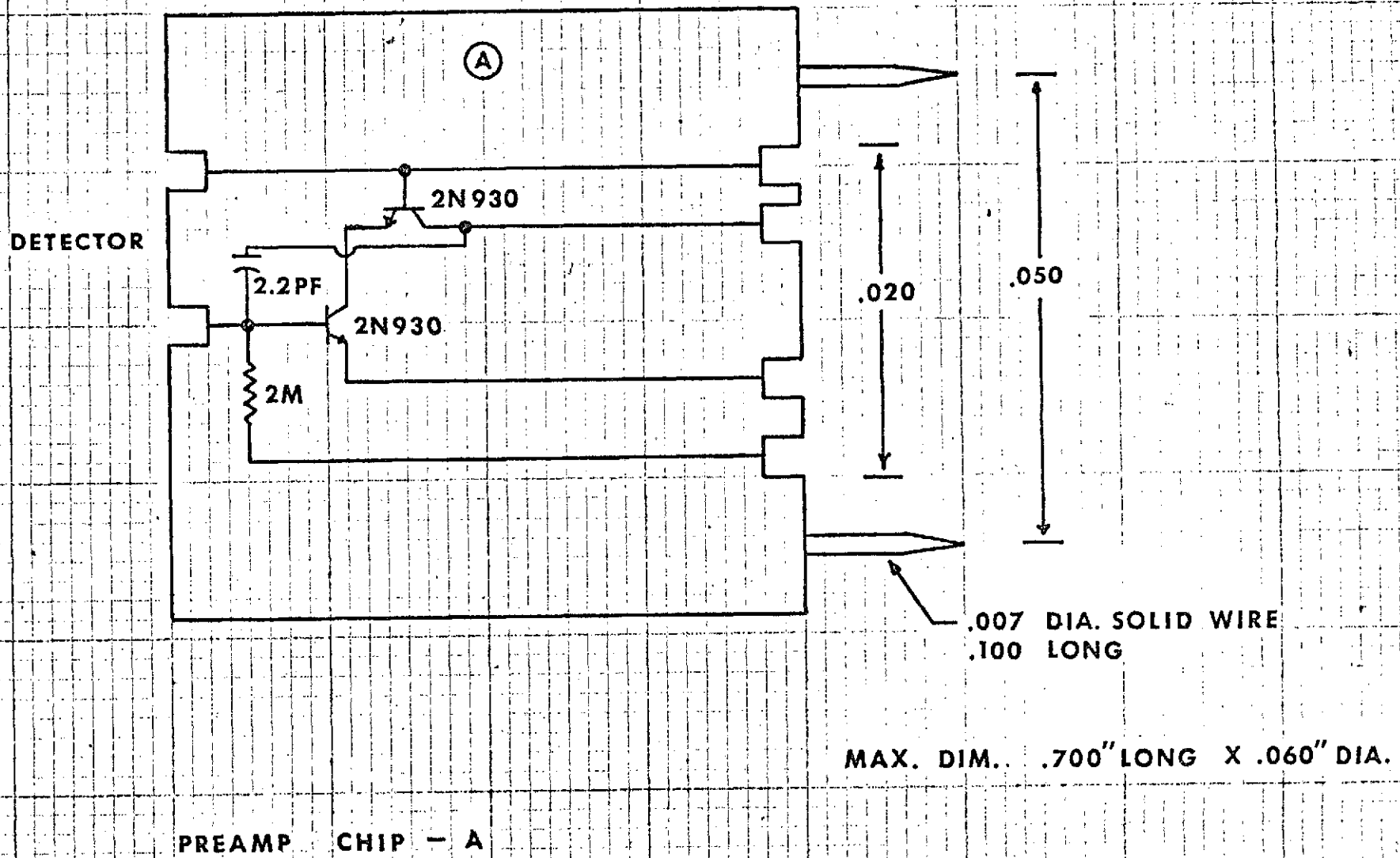




A — PREAMP  
 B — DETECTOR  
 ALL UNITS IN INCHES

SOLID STATE RADIATION PROBE — CATHETER

GLM — 35



### CATHETER TIP PREAMPLIFIERS

Charles J. Laenger, Sr. and Robert L. Wilbur  
Southwest Research Institute  
San Antonio, Texas

C. P. McGraw, Ph.D.  
University of Texas Medical School at Galveston  
Galveston, Texas

Special purpose preamplifiers must be an integral part of certain medical diagnostic and physiologic data acquisition transducers. One such diagnostic instrument currently in development is the catheter tip, solid state radiation detector used to measure beta radiation level in blood. The physical requirements of this transducer assembly are that it be: (1) less than 0.100" in diameter and less than 0.5" long, (2) biocompatible and non-thrombogenic, and (3) gas sterilizable. General electrical specifications are that the unit be safe for both the patient and the physician and that it be compatible with a solid state radiation detector element.

Irreversible brain damage can occur when blood flow to the head is restricted. It is essential for best treatment and care, therefore, to monitor blood flow to the brain of patients who have sustained head injuries.

Researchers are attempting to use an isotope (Krypton-85) in developing a means for measuring cerebral blood flow. Head-injured patients are administered the gaseous isotope with a respirator and arterial and venous beta radiation levels are measured. Comparison of radiation level in the blood entering the brain via the carotid artery and in the blood returning from the brain via the jugular vein may provide an acceptable means for measuring blood flow to the brain. Presently it is necessary to withdraw blood samples each time a measurement is made - a procedure which involves discomfort and potential danger of infection to the patient.

The solid state radiation probe, including a tip-mounted solid state preamplifier, has been incorporated within an intra-vascular catheter. See Figure 1. These catheter tip transducers can be inserted into the carotid artery and jugular vein where they can remain in place for extended periods. "On demand" monitoring of cerebral blood flow can thus be achieved without repetitive withdrawal of blood samples. This method

may vastly improve methodology for monitoring cerebral blood flow. It could prove more rapid and reliable for determining the extent of head injuries, progress towards recovery, and the effectiveness of therapeutic treatment.

The solid state radiation detector used in the catheter tip transducer is a lithium compensated silicon device developed and marketed by Solid State Radiations, Inc. See Figure 2. The basic circuit for providing bias voltage and for preamplification of the electrical pulses resulting from detected beta activity was also developed by Solid State Radiations, Inc. The NASA Langley Research Center modified the circuit and fabricated the preamplifier for catheter tip mounting. Southwest Research Institute, under contract with NASA Technology Division, assembled and packaged the complete catheter which included a post-amplifier mounted at the proximal end. In vitro tests were made with dry Krypton-85 and preliminary intra-vascular tests have been made with experimental animals.

The most significant engineering achievement was development of the pre-amplifier package which is nominally 0.065" in diameter and 0.4" long.<sup>1</sup> See Figure 3. Electrical requirements and specifications are as follows: supply voltage -  $\pm 22.5$  volts dc (battery); current drain - 200  $\mu$  amps; gain - 4; and noise output - 336  $\mu$  V<sub>RMS</sub> referred to input with the detector in place.

#### Acknowledgements:

This effort was funded by NASA Technology Utilization Division, Washington, D. C.

The authors acknowledge the cooperation and valuable consultation provided by Mr. John H. Ewins of Solid State Radiations, Inc.

1. Accomplished by Mr. Charles Nichols at NASA Langley Research Center.

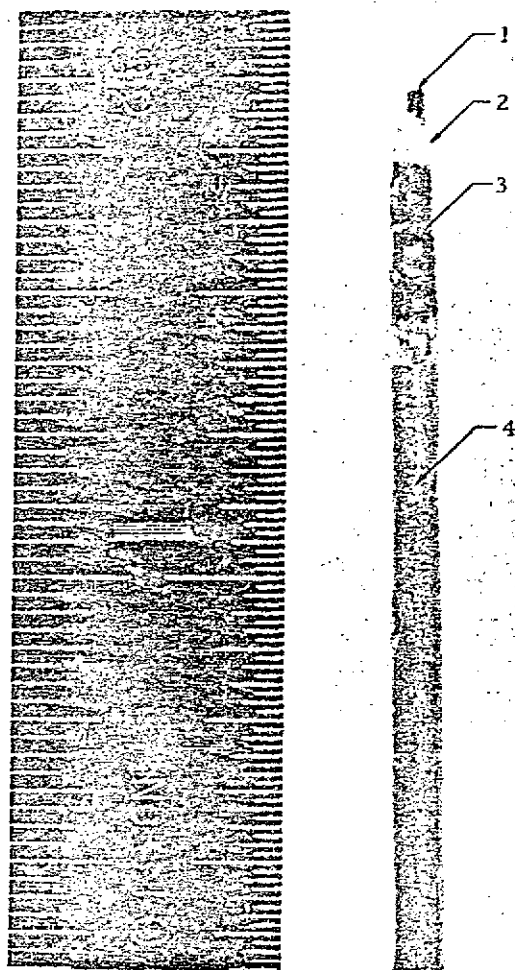


FIGURE 1. BETA RADIATION CATHETER  
TIP TRANSDUCER

1. SOLID STATE BETA RADIATION  
DETECTOR ELEMENT
2. POTTING MATERIAL - SCOTCHCAST #5
3. PREAMPLIFIER
4. USCI NO. 5910 CATHETER #7 FRENCH -  
0.092" O.D.

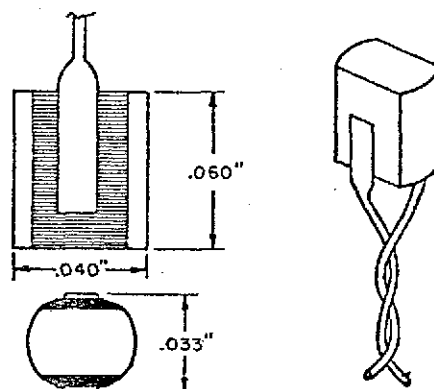


FIGURE 2. SOLID STATE RADIATION  
DETECTOR ELEMENT  
(DEVELOPED BY SOLID STATE  
RADIATIONS, INC.)

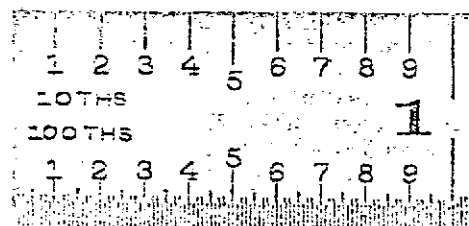
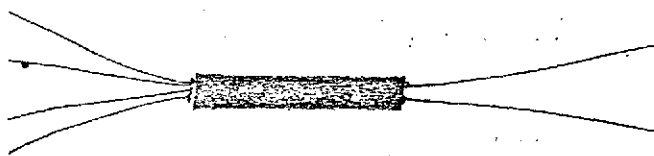


FIGURE 3. PREAMPLIFIER

POTENTIAL TECHNOLOGY APPLICATION

Problem: MDA-1 RADIATION RESISTANT TILT TABLE  
MATERIAL FOR RADIOTHERAPY

Institution: M. D. Anderson Hospital  
Houston, Texas

Investigator: David H. Hussey, M.D.  
Radiotherapy

Acquisition  
Date: August, 1972

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PROBLEM OBJECTIVE

Investigators asked NASA help in locating or developing materials for design and fabrication of a radiotherapy patient tilt table which does not accumulate large amounts of radiation from neutron bombardment.

BACKGROUND

The investigators are in the developmental stages of massive tumor treatment by fast neutrons generated by bombarding Beryllium with Deuteron. They have use of the cyclotron facility at Texas A&M University. Present problems center around finding a suitable material from which to fabricate the patient tilt table. This material ideally should be able to withstand the bombardment of thermal and epithermal neutrons without accumulating a great deal of radioactivity because replacing contaminated radiotherapy equipment is extremely prohibitive.

APPROACH AND STATUS

Through the NASA STIE search T641 which is on record for reproduction and update, the BATEam took note of several documents that referred to a NASA developed class of polymers called pyrrones. NASA document SP-5075 included an article entitled "Properties and Potential Applications of a New High-Temperature Polymer, Pyrrones," p. 165 that gave basic outlines for the feasibility of considering this material as a solution. (portion of document is included after this summary).

Through the efforts of Warren Kelliher and Vernon Bell at Langley Research Center, the BATEam was able to acquire several samples of the material in different configurations. The investigators were extremely enthusiastic about the pyrrones, and are presently completing radiation testing in their facility. Mechanical properties testing is due to begin shortly. It will be noted that this particular material is available in several forms, including films, coatings, laminates, foams, and moldings. We suggested that a laminate coating of the regular radiotherapy equipment might suffice to provide the kind of protection desired. Since the material is not yet commercially available, and the application technology is highly specialized, Langley Research Center, has expressed willingness to assist in the realization of this material utilization.

Another suggestion put forth by John A. Parker at Ames Research Center was the use of another class of polymers which are commonly radiation resistant. These are the polycyclic aromatic types. Parker stated that it is the metals in the polymer chains which absorb the neutron radiation, and that, by careful processing, the metals could be eliminated from the polymer, since they do not contribute to the structural properties. An organic acid (EDTA) could be used to chelate the metals through precipitation. Then, metal-free monomers could be vacuum deposited onto the formed surface to produce a radiation-free cover.

Parker also suggested an alternative plan. Existing radiotherapy patient tilt tables could be kept in use by simply using a disposable dressing cloth impregnated with a neutron-captive dressing (such as "borax"). This is within the present capabilities of paper manufacturers and should be relatively inexpensive. Since the main radiation hazard of this equipment was for the technician and not the patient, the idea of utilizing a treated paper seems feasible.

## 24. PROPERTIES AND POTENTIAL APPLICATIONS OF A NEW HIGH-TEMPERATURE POLYMER, PYRRONES

By Warren C. Kelliher  
Langley Research Center

### INTRODUCTION

The pyrrones are a new class of polymers that have been developed at the Langley Research Center for high-temperature environments. The polymer is a thermosetting-type resin resulting from the reaction of an aromatic tetraamine with an aromatic dianhydride. (See fig. 1.) The two monomers initially react to form an intermediary stage having a nylon type of structure. At this stage the polymer is tractable and forms the basis for fabricating the polymers into useful end products. By use of a thermal-curing process, the polymer loses water, forms initially a polybenzimidazole (PBI) or polyimide (PI) structure, and then fully cyclizes to the pyrrone structure. The PBI and PI are commercially available high-temperature resins and have a step-ladder structure as schematically shown in figure 1. The pyrrones, however, being fully cyclized have a full-ladder type structure, are more rigid, and have different properties than the PI and PBI resins.

The two available forms of the intermediate stage of the polymer are shown in figure 2. The solution form can be obtained by using a variety of solvents and is generally used for producing films and coatings. The solution or varnish, as it is sometimes called, is suitable also for making laminates, since a solids content of 35 percent in the varnish can be obtained. The powder is a fine, free-flowing material used for the production of foams and moldings.

### DISCUSSION

Some of the forms that have been fabricated from the pyrrone intermediate stage are shown in figure 3 and are:

(1) Films - The films have high strength, little elongation, and reflect the rigid nature of the pyrrone polymers. The investigation of the properties of the films has shown a potential application as a membrane or a separator in electrolysis systems.

(2) Coatings - Solutions of the high-molecular-weight pyrrone intermediate stage have a natural film-forming tendency and also have good adhesive properties. As a result, excellent coherent coatings on a variety of substrates can be obtained. The thermal and

chemical stability of the pyrrones suggest potential application of the coatings where high-temperature corrosion resistance is required.

(3) Laminates – Much of the applied research on pyrrone resins has been in the area of fabricating and testing of laminates for high-temperature structural applications. The high rigidity of the pyrrone resin structure results in laminates having high flexural strengths, and the good adhesive properties of the intermediary solution stage results in laminates with high interlaminar shear strengths. At the present time, the long-term high-temperature properties of the pyrrone laminates are being investigated in combination with different reinforcing agents.

(4) Foams – Because of the volatiles given off during the thermal curing process, the pyrrones have a natural tendency to foam. This property presents some difficulty in producing quality laminates and moldings. Because of the high-temperature stability and high strength of these foams, they are currently being evaluated for use as ablative materials and as a structural core material. Foams with densities as low as 15 lb/ft<sup>3</sup> that possess good mechanical strength properties have been obtained.

(5) Moldings – Unfilled moldings have been produced at the Langley Research Center and are being used as a means to evaluate the properties of the cured resin system. An investigation of filled moldings has just begun and good results have been obtained with 50 percent loading levels of aluminum, mica, molybdenum disulfide, and graphite in pyrrone.

For comparison with other polymers, the more significant strength properties of different fabricated forms of pyrrone resins are presented in figure 4:

(1) Films: For 1 mil thickness film – high tensile strengths, 20 000 psi; low elongation, 6 percent.

(2) Laminates: For 12 ply, glass-reinforced laminates – high flexural strength, 90 000 psi; high modulus strength,  $5 \times 10^6$  psi; good horizontal shear strength, 5000 psi. When tested at 600° F, retains 80 percent of room-temperature strengths.

(3) Foams: For unreinforced 30 lb/ft<sup>3</sup> density foams – high compressive strength, 2000 psi; high modulus strength,  $1.3 \times 10^5$  psi.

(4) Moldings: For unreinforced moldings – high flexural strength, 18 000 psi. When tested at 600° F after 100 hours at 600° F, they had 15 000 psi flexural strength and 3000 psi flexural strength at 1000° F.

The general properties of the pyrrone polymers are:

(1) Nonflammable – It can be heated to incandescence without flammable combustion



(2) Outstanding radiation resistance – Although most polymers suffer degradation after 5000 Mrads of radiation, the pyrrones were subjected to 50 000 Mrads of radiation and had no detectable degradation of properties

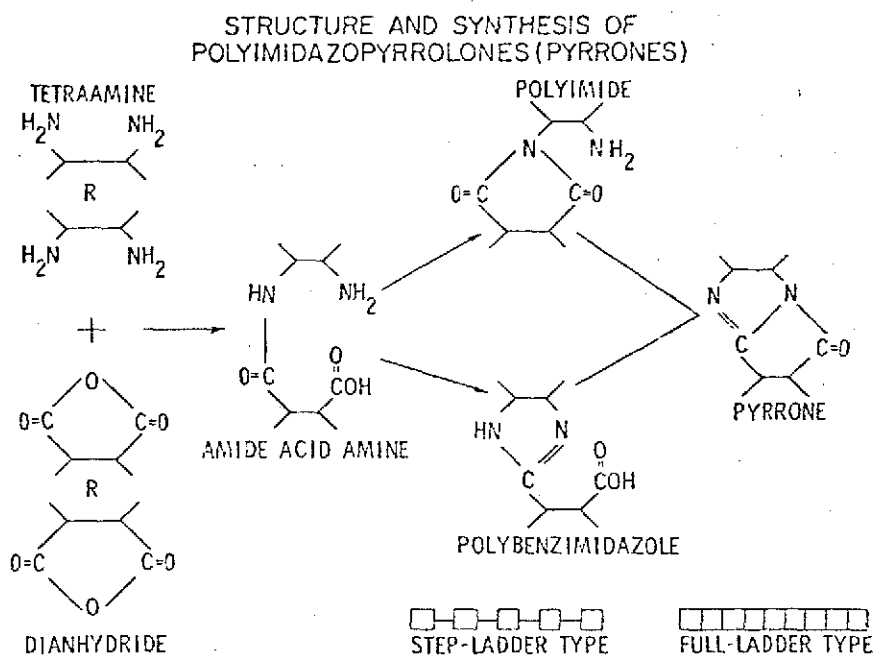
(3) High-temperature stability – Pyrrones have long-term stability to at least 500° F and potentially to 600° F; short-term stability to 1000° F

(4) Good adhesion, coatability, and corrosion resistance – Pyrrones have excellent potential as high-temperature corrosion-resistance coatings; 1000 hours at 150° F in 40 percent sulfuric acid and potassium hydroxide had little effect on the resin

(5) Easy to machine – Because of rigid nature of the polymer, it is very easy to perform normal milling, cutting, and sanding operations on the cured resin.

### CONCLUDING REMARKS

It must be emphasized that the pyrrones are a new class or family of polymers and these polymers have different chemical and mechanical properties depending on the starting monomeric materials. At Langley Research Center the polymers are being developed and their properties are being investigated from the standpoint of space and aeronautical utilization. The polymer does, however, have some very interesting and useful properties that could have commercial applications. Its development for these purposes and potential usage is left to the initiative of private enterprise. The polymer is available in research quantities from the Langley Research Center and from two contractors, Hughes Aircraft and Avco Corp., who are assisting in the optimization of the mechanical properties of the polymer. Additional details on these polymers can be obtained from the Langley Research Center.



POTENTIAL TECHNOLOGY APPLICATION

Problem: MSC-1 PORTABLE SCALP COOLING DEVICE FOR  
CHEMOTHERAPY

Institution: Louisiana State University Medical Center  
New Orleans, Louisiana

Investigator: Jose E. Torres, M.D.

Acquisition  
Date: December, 1972

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## PROBLEM OBJECTIVE AND POTENTIAL APPROACH

Liquid-cooled garments have been developed by NASA to be worn under pressure suits in high-temperature environments. It has been suggested that technology generated during development of the LCG may have an important application in cancer treatment. Certain fast-growing types of cancer cells have been shown to be particularly sensitive to treatment by cytotoxic drugs, resulting in a marked upsurge of clinical research into techniques of cancer chemotherapy. One of the common undesirable side-effects of chemotherapy is temporary, but complete loss of hair. Preliminary efforts to apply NASA skin-cooling technology have demonstrated that cooling the scalp during chemotherapeutic treatment can prevent attendant hair loss. Temperature differential and treatment time duration parameters are presently unknown, a shortcoming due primarily to the unavailability to the researchers of specific control and measurement equipment.

It is suggested and desired that the LCG technology and equipment be developed to provide a basic system for skin cooling, temperature sensing and temperature controlling to further the research toward understanding and utilizing this potentially valuable therapeutic technique.

Although success is cautiously acknowledged, treatment by direct injection of specific cytotoxic drugs (chemotherapy) is being used with encouraging frequency for certain fast-growing forms of cancer, including lymphatic leukemia, Hogkins disease, and choriocarcinoma (occurs in placenta of some pregnant women).

It was suggested by the investigators that locally reducing metabolic activity (including circulation) by cooling the scalp region might help to prevent, or reduce, hair loss attendant to chemotherapy. The theory received cursory trial on one patient, using cooling equipment and personnel assistant from CSD of NASA/JSC, with the result that hair-loss was very slight.

Enthusiasm among the investigators has thus been heightened by the indication of probable success in applying their theories. They have begun preparations for developing protocol for more extensive studies of the local cooling technique. Besides preventing hair loss, it is also foreseen that the technique may be applied toward reducing aplastic anemia (also a side-effect of chemotherapy) and to potentiating (localizing) chemotherapeutic effects.

The researchers need a portable means of cooling body surface areas, including scalp, sternum, and hips to surface temperatures as low as 50°F. The device should be a self-contained, closed circulatory system, portable unit which includes measurement capabilities for inlet and outlet coolant temperatures, skin surface temperature, and coolant flow rates. The unit would preferably use a closed system for circulating chilled water and a heat-exchanger interface to a gas coolant (similar to the LCG concept). It would receive power from a standard 115V AC source and needs no further connections at the treatment site.

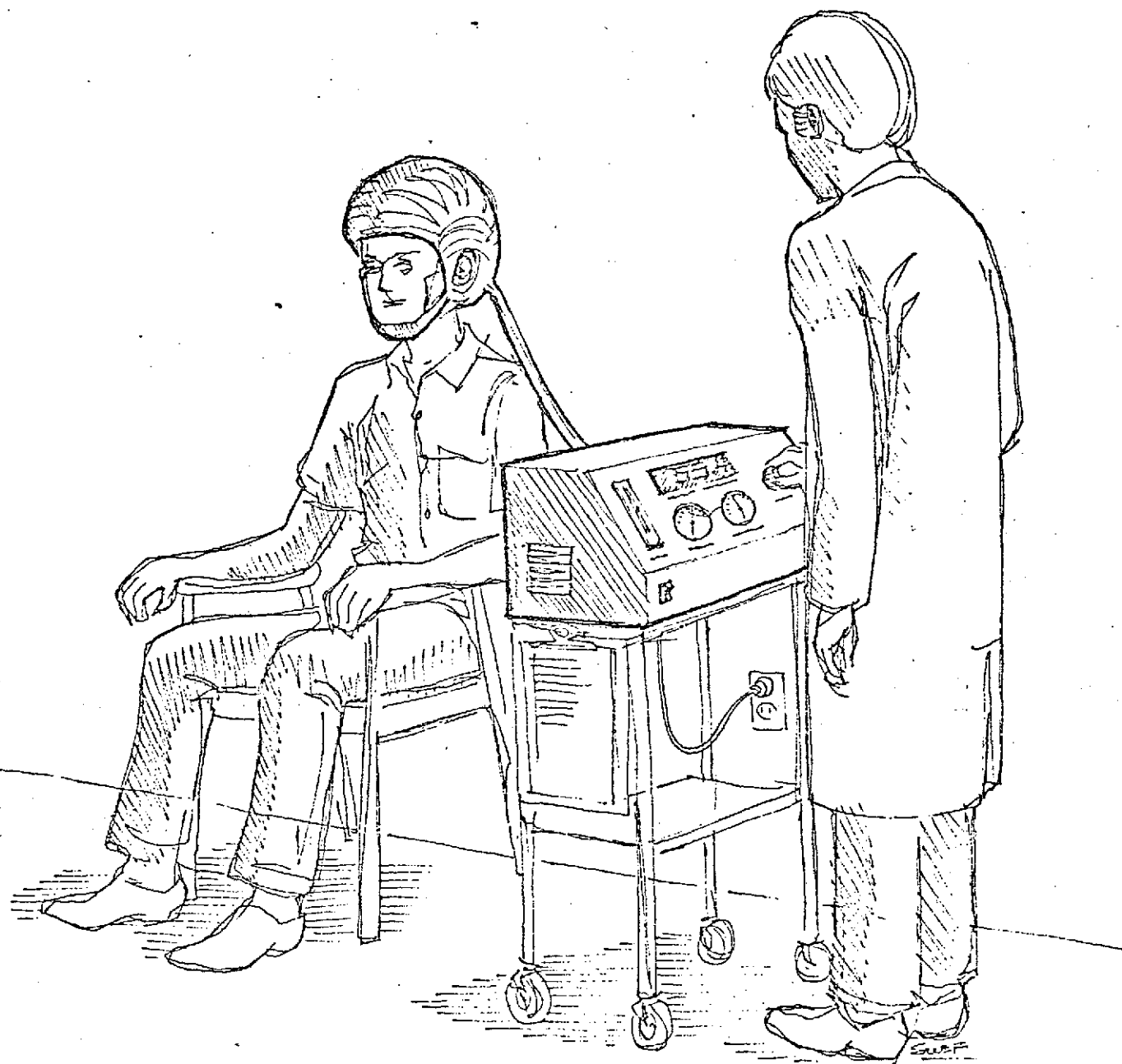
The prescribed technical approach might be divided into three impact areas, any one of which, if not all, may receive input from established NASA technology.

1. Skin contact interface device in the form of a skull cap or deformable blanket,
2. Coolant supply and temperature regulating console,
3. Temperature sensing devices to accurately describe skin temperature.

The interface which cools the skin surface should be a terminal for a closed liquid-circulating system. It should be either preformed to a cap configuration, or deformable to the curvature of the skull. It should consist of a network of channels for coolant circulation with reinforcement sufficient to prevent either channel collapse or ballooning under circulating fluid pressure. It should provide accommodation for skin temperature sensors and for attaching and holding itself to the prescribed area of the body where cooling is to be accomplished. Finally, it should be formed of such material as to be both non-irritating to epidermal tissue and readily sterilizable for repeated use.

The coolant supply should provide a means for cooling the circulating fluid of the interface device and sufficient controls for regulating coolant temperature and rate of flow. It should be semiportable and require only AC house current external connection. It should be permanently or easily attached to the interface device. It should, further, contain a means for reading the skin temperature.

The temperature sensor(s) should be developed with adequate thermal coupling means as to provide accurate and rapid acquisition of temperature changes at the skin surface. Readout should be at the coolant supply console.



SCALP COOLING - A CONCEPT

POTENTIAL TECHNOLOGY APPLICATION

Problem: OVA-2 MEASUREMENT OF LUNG COMPLIANCE

Institution: Veterans Administration Hospital  
Oklahoma City, Oklahoma

Investigator:

Acquisition  
Date: July, 1970

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## PROBLEM OBJECTIVE

Investigators are searching for a reliable, easy-to-use atraumatic method for measuring lung compliance (elasticity).

## BACKGROUND

In emphysema, the prime research target of the investigator who is trying to shed more light on the disease state, the lungs lose their elasticity because walls between adjacent alveoli break down resulting in formation of large air spaces. As a result, physiologic dead space is greatly increased; inadequate and uneven alveolar ventilation occurs and severe anoxemia (reduction of oxygen content of the blood) and hypercapnia (excess of carbon dioxide in the blood) develop. Inspiration and expiration are labored, and the work of breathing is greatly increased.

Presently, unless highly sophisticated systems are employed, information concerning lung compliance can be obtained by inserting a pressure measuring device into the nose and clipping the nose shut. The patient then mouth breathes through an apparatus that contains valve just beyond the mouthpiece. After he inhales a given amount, the valve is closed, interrupting the airway. The patient then relaxes his respiratory muscles while the airway pressure (now equal to pressure in the lungs) is recorded. The procedure is repeated after actively inhaling or exhaling various volumes. The airway or lung pressure obtained is plotted against volume as shown in the following figure.

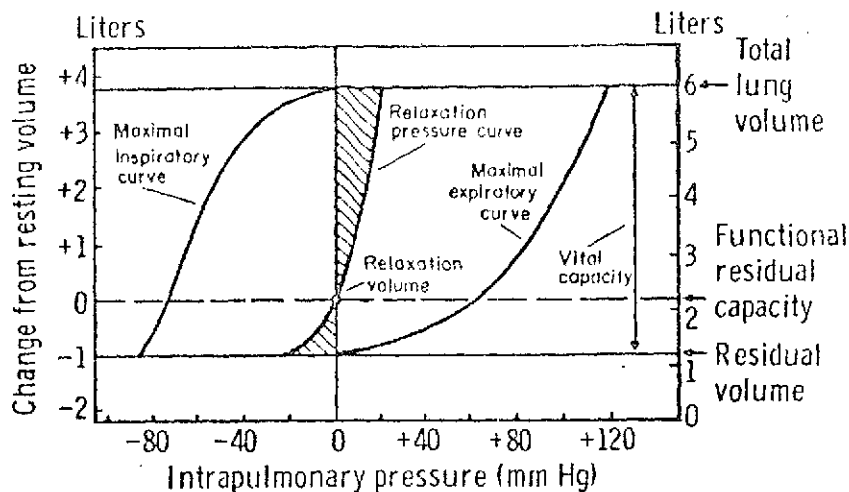


Diagram showing the relation between intrapulmonary pressure and volume. The center curve represents the static pressure curve of values obtained when the lungs are inflated (or deflated) by various amounts and the intrapulmonary pressure measured with the airway closed. The slope of the curve represents the compliance of the lungs and chest wall. The maximal inspiratory and expiratory curves are the airway pressures that can be developed during maximal inspiratory and expiratory efforts (Ref: MEDICAL PHYSIOLOGY, 11th ed., P. Bard, ed., Mosby, 1961)

As can be seen from the above figure, the pressure is zero at a lung volume that corresponds to the volume of gas in the lungs at the end of a quiet expiration (termed the functional residual capacity); positive at greater volumes; and negative at smaller volumes. The change in lung volume per unit change in airway pressure ( $\Delta V/\Delta P$ ) is the "stretchability" or compliance of concern to the investigator. In young individuals, the normal value of compliance is about 0.1 liter/cm of  $H_2O$ . However, when rigidity of the lungs increases, this index value drops and is particularly low in the presence of emphysema.

Acquisition of compliance data by the means described above is time consuming, requires the use of bulky equipment, and is difficult to employ with patients who are ill. While the technique is sensitive enough for gross diagnostic usage, it is inadequate for detecting subtle abnormalities or changes in the disease state. The existing method for acquiring lung compliance data must be utilized with care because the associated flow transducer is not reliable. One component of the air volume measurement apparatus is a screen which often becomes partially clogged due to presence of moisture in the exhaled air. The problem has existed in the field of pulmonary instrumentation for a long time, and although many modifications and alternate approaches have been explored, it has not yet been satisfactorily solved.

## APPROACH

There have been three apparently viable potential solutions proposed for this problem:

1. From the Naval Ordinance Lab, Dr. Sherman Gee:

To determine compliance by driving the combined volumes of instrument and lungs with a known incremental pressure fluctuation. The phase shift in pressure response would be sensed at each of several static pressure references to provide a spectrum of compliance values.

2. From SwRI, Wendell R. Peters (based upon work done previously by him at School of Aerospace Medicine, Brooks, AFB):

Uses a fast Fourier transform algorithm (spectral analysis techniques) to convert flow data output from random pressure input into amplitude phase versus frequency data readily reduceable to known parameters of dynamic behavior of lung disease.

3. From NASA/Langley Research Center, Mr. Otto Trout:

Applies a flow-volume loop graphical display as has been used in prototype form at Langley for a 90-day manned test using a spirometer and assorted recording means.

A great deal more is known currently about lung compliance, but bioinstrumentation and data gathering techniques are not yet completely satisfactory.

Three current references are listed for information purposes:

1. "Stress distribution in lungs: a model of pulmonary elasticity," Mead, Jere, et al, in J OF APPLIED PHYSIOLOGY, 28:5 May, 1970, p 596 begin.
2. "Tests of a model of pulmonary elasticity," J OF APPLIED PHYSIOLOGY, 33:5, Nov., 1972, p576 begin.
3. "A New Method for Simultaneous Measurement of Total Respiratory Resistance and Compliance," Miyamoto, Yoshimi, et al, in JAP J PHYSIOLOGY, 22, 453-466, 1972.

# POTENTIAL TECHNOLOGY APPLICATION

Problem: SDU-1 COMPLETE PORTABLE SYSTEM FOR ACQUIRING  
AND ANALYZING AUDIO EVOKED RESPONSES

Institution: University of California at San Diego  
La Jolla, California

Investigator: Robert Galambos, Ph.D.  
Neurosciences

Acquisition

Date: April, 1973

## ----- PROBLEM OBJECTIVE

The investigator would like a portable, compact and complete system for acquiring, analyzing and recording audio evoked responses.

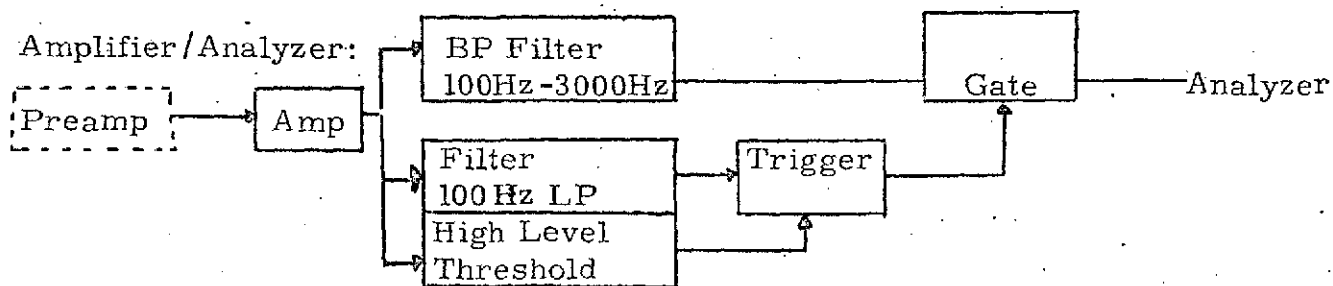
## BACKGROUND AND SPECIFICATIONS

A new test of hearing capability of newborns uses only the first 10 milliseconds of the auditory evoked response and is presently being measured with a cumbersome agglomeration of commercial equipment, including Grass amplifiers and a computer of average transients. It is very difficult to transfer this equipment within the hospital, and is impossible to use the system in intensive care areas because of bulk.

The investigator states the following specifications:

### Stimulator Section:

1. Bandwidth - 1/3 octave noise centered at 800, 1500 and 3000 Hz,
2. Level Control - 0 to 110 dBre .002 dynes/cm<sup>2</sup>,
3. Electrodes - Built-in preamplifiers and good 60 Hz rejection.





1. Interrupt input to analyzer when motion artifact or muscle potentials are present. That is, do not record in the presence of very low frequency signals and/or high amplitude signals.
2. Information immediately after stimulation is very important (labeled I, II,....IV).
3. Analyze 2,000 repetitions - automatic cutoff needed.
4. Modified CAT - a high-speed, special purpose analyzer.
5. Good 60 Hz rejection.
6. Readout: (a) Visual, with points plotted at 100 usec. intervals, and (b) plotted record required.

#### SUGGESTED APPROACH

Marshall Space Flight Center is currently finishing up work on an evoked audiometric system that comprises most of the technology needed by the investigator. System description is included in the discussion of problem SWC-2. Pending their completion and evaluation testing, a clinical adaptation with improved portability could be considered.

Depending upon working relations with the investigator, personnel at Goddard at one time were willing and able to give the problem additional input suggestions. A renewal of these contacts would be desirable.

POTENTIAL TECHNOLOGY APPLICATION

Problem: SWC-2 EVOKED CORTICAL AUDIOMETRY MEASUREMENTS

Institution: Scott and White Clinic  
Temple, Texas

Investigator: L. H. Deiterman, Ph.D.

Acquisition October, 1970

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## PROBLEM OBJECTIVE

Investigators sought to explore NASA developed basic state-of-the-art electronic circuitry which can be incorporated into an instrument to supply audio tones, synchronize and signal condition the EEG for recording of evoked responses on infants and preschool children.

## BACKGROUND

The investigator would use the instrument to clinically test infants for evoked cortical responses (EEG) to audio stimuli to determine if a child is deaf, hard of hearing, or has brain damage not directly related to hearing ability. The introduction of a clinical instrument that will discriminate between hearing difficulties and other brain defects will promote proper treatment of small children with hearing defects without the erroneous diagnosis of mental retardation. Evoked cortical response testing is not new, however, no instrument exists for testing the hearing of subjects by this method.

## APPROACH AND STATUS

Because of their interest and facility capabilities, personnel at Marshall Space Flight Center have taken over the development of this system. After lengthy periods of design, fabrication, and components development, the system is now due for final completion sometime this fall.

A complete description of the system as it stands is documented in the MSFC document S&E-ASTR-RMH-72-7, Sept. 21, 1972 entitled "Development of a Portable Evoked Cortical Response Audiometrics System," by Stephen M. Graff and Robert V. Allen.

For documentation and informational purposes, excerpts from that document are either quoted or paraphrased here:

Abstract-"An evoked cortical response audiometrics system was developed using hybrid microcircuit techniques. The system delivers an audio burst to the patient to evoke an EEG cortical response. This response can be evaluated to detect a possible hearing loss. The basic system consists of a helmet containing ear phones and EEG probes, a preamplifier, a signal conditioner, an audio oscillator, a waveform averager, and a strip chart recorder. The preamplifier and signal conditioner were fabricated using thick film technology and packaged at the base of the helmet. This technique appreciably reduced system noise, size, and stray transients. Hybrid techniques permit the system to be packaged as a portable unit, and enable an audiologist to administer audiometric tests to a patient outside of the laboratory."

Evoked Response Theory - Basically, evoked response theory is the application of the measurability of cortical brain waves and the brain's electromagnetic reaction to stimulation. If an auditory stimulus is applied, the brain has a specific reaction (AER and CNV). These two main stimulus responses will occur first and will be waveform with a frequency of approximately 50 Hz. The CNV will follow and is the dc shift in the wave pattern. Approximately 50 ms after stimulation, AER occurs. This is the average reaction time for the human brain. This measure of the reaction time can be used to evaluate several medical problems and will be discussed in other sections of the report.

Conventional Systems - Audiometers and Evoked Response  
 "The conventional audiometers in operation today do not utilize EEG technology. For these systems an auditory stimulus is administered to the person under test. The person responds by a predetermined physical reaction, such as pushing a signal button or raising his hand. Handicapped persons or infants with physical limitations are difficult to test and test results are usually inconclusive. The audiometer is usually contained in a desk console and requires a shielded soundproof room where the person under test is located. Due to the nonportability of this system, persons must be tested at either a laboratory or a clinic. Thus only a limited number of persons can be tested and a trained audiologist is required to administer and evaluate the test. However, with evoked response systems, if a person hears an auditory stimulus, his brain will react, regardless of his attentiveness. This eliminates the physical reaction problems encountered with the audiometer. Thus, infant and handicapped persons can be tested because a physical response is not required. The conventional evoked response audiometric systems are not portable. They require a console for equipment and a shielded room for noise reduction. A simple method of probe attachment is not available with these systems. Conventional evoked response audiometric systems with the circuits packaged on metal chassis are very susceptible to random noise. To eliminate the random noise signals, a waveform

averager is required. The waveform averager digitizes and records the signal in memory. After several sets of data are recorded, the sets are averaged. Then, the results are printed on a strip chart recorder. There is also a problem or component transients in the conventional systems. These slight changes in value of the components within the system can cause inaccurate data measurements.

A presentation of the complete system design and description will be presented when the technology application is completed.

# POTENTIAL TECHNOLOGY APPLICATION

Problem: TCB-20 DEVICE TO ENABLE BLIND DIABETICS TO  
SELF-ASSESS URINALYSIS TESTS

Institution: Texas Commission for the Blind  
Criss Cole Rehabilitation Center  
Austin, Texas

Investigator: Jim Caylor  
Director of Assessment

Acquisition  
Date: May, 1973

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## PROBLEM OBJECTIVE

A device is needed that will enable blind diabetics to self-assess urinalysis tests.

## BACKGROUND

Diabetes is second only to glaucoma in the United States as the leading cause for blindness. So, not only do these people have to deal with their sight deficiency and all the rehabilitation that is necessary, but they have to deal daily with added physiological dysfunctions. Part of the diabetic care regimen is taking an almost daily urinalysis test. Blind diabetics can easily perform the test, but must refer without fail to a sighted individual for assessment of the test results (currently read by comparison of the sample soaked litmus paper to a standard color chart).

Investigators would like to pursue NASA's photocell technology to come up with a one to one, cost-effective jig device which can audibly or tactually assess the proper color level associated with a positive or negative result.

## APPROACH

David Winslow of Marshall Space Flight Center has been most gracious in providing the SwRI BATEam with solution suggestions. Parts of his concept are presented here as a potential approach, which are presently under study by the SwRI BATEam which has the engineering and facility capability to pursue the implementation of the approach.

Colorimetric determinations are now standard in almost all medical laboratories. Photoelectric instrumentation measures

the absorption of specific frequencies of light by solutions to determine the concentration of the desired component of the blood, urine, and so forth sample.

It is proposed that a very simple device that would measure the relative color shift be constructed. A simple light source will shine on the test strip after it has been dipped into the urine and the color changes have developed. A detector such as a photocell or photoresistor will be focused on the specimen carrier so that it will "see" only the colored light "reflected" by the test strip. The circuitry will provide an audible signal of which the frequency or volume is a measure of the intensity of the light received by the photocell or other detector. A color filter disc is inserted in the light path between the specimen and the photocell. Ideally, the filter will be a continuous type, that will cover the same range of colors as those exhibited by the specimen, and would be either of linear or circular shape so that the different shades of yellow-green may be slid or rotated into position.

The user merely slides (or rotates) the color filter until the tone or intensity of the audio circuitry indicates the greatest light intensity (relative) being measured. This will occur when the color of the filter most closely matches the color of the "reflected" light from the specimen that is, any filter will transmit the greatest percentage of light that matches the spectral characteristics of the filter. Also, by listening for the "maximum," the system automatically compensates for any variations in the source light intensity or of the intensity of color of the particular specimen (that is faded versus good, rich color). The user may then determine the filter position by touch; the filter position denotes the relative color shift, and thus the amount of sugar present in the urine.

The only nonstandard item is the variable color filter. The filter has to be matched as closely as possible to the color changes occurring in the chemical "dipstick." One simple approach is to photograph a color illustration (airbrushed) of the continuous color change, and then laminate the resulting color transparency in glass or plastic. An alternate approach is the use of two photocells, one measuring the light source intensity and the other measuring the light intensity after reflection from a printed color chart. This approach is very prone to error since surface irregularities and reflectivity interfere. A third approach is the use of a prism or grating and a slit so that various wavelengths of monochromatic light would fall on, and be reflected by, the specimen. This also presents problems since the intensity of the source will vary with the wavelength and relatively complicated bridges and balancing networks must be used.

It is believed the novelty of this concept lies in the combination of a variable wavelength transmission filter with an audible circuit to measure the color (wavelength) of a specimen. The device may be operated by blind or color-blind individuals, but may be adapted to other applications if desired.

POTENTIAL TECHNOLOGY APPLICATION

Problem: TCD-4 NOISE ACTIVATED FLASHER WARNING  
DEVICE FOR DEAF DRIVERS

Institution: Texas Commission for the Deaf  
Texas Rehabilitation Commission

Investigator: Randy Scott

Acquisition

Date: March, 1971

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PROBLEM OBJECTIVE

A need has been established for a small dash or windshield mounted light flasher activated by usual and unusual auditory driver sounds.

BACKGROUND

A growing number of automobile accidents occur because individuals fail to hear the sounding of a horn or the siren of an emergency vehicle. This is sometimes caused from windows being closed and radio, tape recorder or air conditioner equipment being in operation. Although this is a general hazard (which increases with more elderly drivers on the road), it is particularly significant for deaf drivers because they are unable to hear the warning sounds. It is a severe handicap to be restricted to visual stimuli only in driving safety, and it is even more of a handicap that this should prevent an otherwise intelligent and habilitated individual from being able to drive.

It is desired that the device should be small enough to avoid blocking the driver's view, but be large enough to be seen. Dash mounting or windshield mounting is suggested since they are convenient reference points under usual surveillance by drivers. Sound source could be differentiated by the visual pulse differences. The device should be portable if necessary for rental car drivers, semi-permanent installation models also may be needed.

APPROACH

The original solution approach was suggested by David Winslow of Marshall Space Flight Center, who mentioned the use of conventional bandpass filtering techniques, via a color organ, coupled with an amplifier and a microphone pickup.



The JSC Operational Systems and Planning Branch looked at the problem, and is now considering implementation. They state that they are still in the process of obtaining frequency sound data and noises of concern in evaluating the provided filters.

POTENTIAL TECHNOLOGY APPLICATION

Problem: TTU-3 RATE MONITOR FOR SELF-INJURIOUS  
BEHAVIOR

Institution: Texas Tech University  
Lubbock, Texas

Investigator: William Landers, Ph.D.  
Psychology

Acquisition  
Date: January, 1973

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#### PROBLEM OBJECTIVE

Investigators stated their need for a rate monitor to accurately count the number of self-injurious behavioral responses in order to determine appropriate schedules of reinforcement.

#### BACKGROUND

Within the last ten years, investigators have used various means to effectively suppress self-injurious behavior (SIB) i.e., face slaps, head-to-floor butts, etc. However, a tremendous investment in money and trained personnel are necessary to monitor the retardates' behavior and to consequence their non-SIB with appropriate reinforcement. In addition, with severely retarded individuals, latency of reinforcement (i.e. reward or punishment should be delivered .50 sec. or less to be effective) is extremely critical if the individual is to understand why he is receiving the reinforcement. One of the basic parameters of effective reinforcement is accurate knowledge of the rate of SIB.

The needed monitor should provide a continuous permanent record of the SIB up to a rate of 45 responses per minute. The monitor should be compatible with a 28v DC power supply. Reinforcement will consist of some form of auditory, visual, or tactual stimulation delivered to the retardate contingent upon his non-SIB.

#### APPROACH

Part of the solution approach was to provide the investigators with NASA documentation on the subject of SIB. Search no. T0654 from NASA STIF yielded 130 references that were of significant value to the investigators. The search is on record for duplication and update.

For the device itself, the SwRI BATEam identified NASA Tech Brief B72-10452, "Miniature Intermittent Contact Switch," NASA SP-5094 "Implantable Biotelemetry Systems," and the NASA EEG 'soft cap," which were incorporated into the design considerations of the unit. At this time, the receiver unit has been completed, and the transmitter is under fabrication. Complete details of the device and operational technical discussion will be provided when fabrication and evaluation are finished.

# NASA TECH BRIEF

*Ames Research Center*

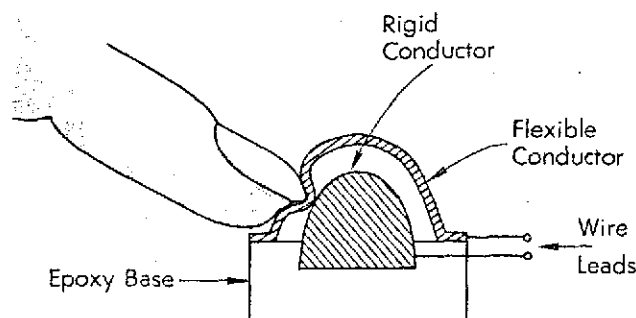


NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

## Miniature Intermittent Contact Switch

### The problem:

To provide a shock-resistant switch capable of being actuated by forces of varying magnitude and direction, primarily for use as a sensor on remote control (tele-operator) and prosthetic devices.



### The solution:

A flexible conductor, such as conducting rubber, is placed a short distance away from a rigid conductor; any slight physical pressure on the flexible conductor will cause it to come into contact with the rigid conductor.

### How it's done:

One form of the switch is constructed as indicated in the diagram. A short length of an appropriately shaped rigid conductor is coated with a low-melting solvent-soluble material such as wax. Then the flexible conductor is wrapped over the coated area and the assembly is firmly fastened on top of a non-conductive material such as an epoxy base. The material between the two conductors is removed by melting, and all traces are cleaned away with solvent so that clean electrical contact can be made. In order to decrease contact resistance of the switch, maximum contact between the two conductors should be maintained.

This fabrication technique is suitable for switches which must be activated by only a few thousandths of a centimeter of displacement. Switches of this form can be made of sizes which are at least one order of magnitude smaller than those commercially available.

The principle of the switch may be used to make a wide variety of switch types. In some variations, no metal at all is used to construct the switches; conductive membranes may be used to provide a disc type switch which can be activated from either side.

### Note:

No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer  
Ames Research Center  
Moffett Field, California 94035  
Reference: B72-10452

### Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42-USC 2457 (f)]; to Stanford University. Inquiries should be addressed to:

Mr. Neal J. Reamers  
Encina Hall  
Stanford University  
Stanford, California 94305

Source: Antony Sword of  
Stanford University  
under contract to  
Ames Research Center  
(ARC-10450)

Category 01

POTENTIAL TECHNOLOGY APPLICATION

Problem: TTU-4 NOCTURNAL ACTIVITY MONITOR

Institution: Texas Tech University  
Lubbock, Texas

Investigator: William Landers, Ph.D.  
Psychology

Acquisition  
Date: January, 1973

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PROBLEM OBJECTIVE

An inexpensive device is needed to monitor the activity of mentally retarded patients during enforced rest periods. The device will provide a real time readout of the frequency and intensity of nocturnal activity.

BACKGROUND

Group living situations for the retarded, emotionally disturbed and criminal are environments that are typically very restrictive socially and perceptually. Routine rest/activity schedules in group living situations are imposed without carefully considering the effects of the surrounding physical environment. A current trend of altering the physical surroundings to counteract the influences of an impoverished environment is being initiated by various institutions at a great expense. An especially large amount of money and time is being spent to provide individual sleeping arrangements on the hypothesis that this will give the retardates a more normal living environment conducive to restful sleep. However, there is no empirical evidence to suggest or disprove the large investments which are being placed into these efforts, due to a lack of basic knowledge of activity/rest cycles of the mental retardates.

APPROACH

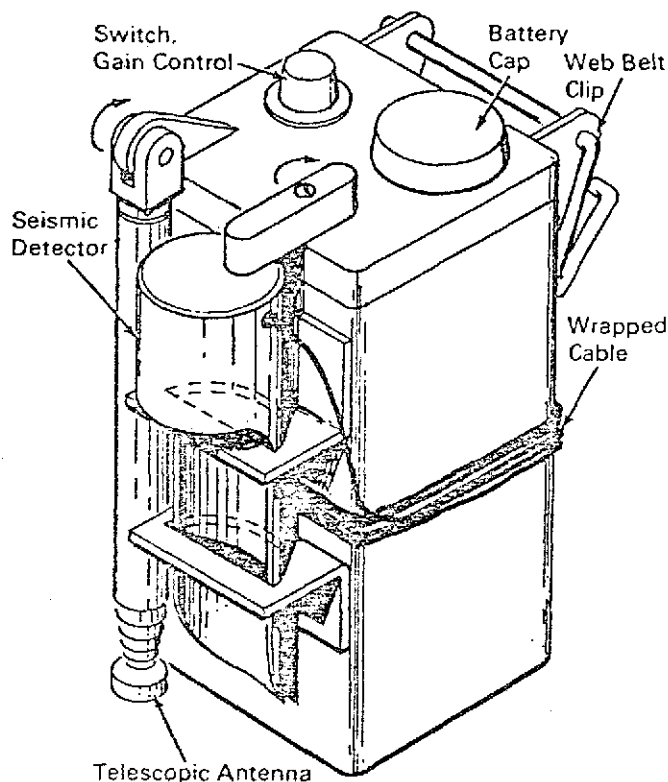
The BATEam has identified NASA Tech Brief B70-10638 for an "Intruder Detection System," developed at NASA/Ames. The system, which is based on seismic principles, has been discussed with the originators who helped to confirm the feasibility and cost effectiveness of utilizing the concept. At present, the work is in the conceptual design stages. The investigators have expressed enthusiasm, and feel in this case, it could prove more advantageous and cost-effective than resorting to ultrasonics.

# NASA TECH BRIEF



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## Intruder Detection System



amplified, and transmitted to a remote radio receiver which provides the listener with an aural signal of disturbances caused by the motions of the intruder.

### How it's done:

The basic intruder detection system is comprised of two units; the intruder detector and the portable FM radio receiver. The intruder detector (see fig.) consists of a seismic detector, of the type commonly used in oil exploration work, connected by a 10- to 20-foot cable to an electronics package which is enclosed within a watertight container. The geophone is potted within a stainless steel tube; one end of the tube is sharpened so that it can be implanted vertically into the ground.

When an intruder moves within range (up to 80 meters) of the seismic sensor, the moving coil vibrates mechanically at its natural frequency; the amplitude and duration of the vibration depend on the intensity of the footstep impulse and the damping factor of the seismic detector. The vibration of the moving coil sensor generates a voltage impulse proportional to the velocity of its mechanical motion, and this low-level signal voltage is amplified.

The amplifier gain is selected to permit detection of disturbances above the ambient seismic background noise and at the highest sensitivity permitted by local soil characteristics. The amplified voltage is detected and integrated. A pulse amplifier triggers the rf oscillator and the audiofrequency voltage-controlled multivibrator (VCO), and their frequencies remain constant until the voltage pulse starts to decay. The exponential voltage decay varies both the frequency of the rf oscillator and the VCO multivibrator. The CW-FM pulse from the rf oscillator is further amplitude-modulated by the VCO voltage within the rf power ampli-

(continued overleaf)

### The problem:

Develop a small, rugged, battery-operated system, capable of detecting the presence of intruders, which transmits information to a portable receiving station on the number or kind of intruders and their speed of movement.

### The solution:

Utilize one or more commercially available, moving-coil geophones to detect the seismic disturbances caused by intruders. The seismic disturbances sensed by each geophone are converted into electrical signals,

fier and then transmitted to a remote FM radio receiver.

The FM radio will emit a single tone burst for each footstep of a slow-walking intruder; a running intruder will cause production of a continuous tone, with audible periodic variations of background noise indicating each footstep.

**Notes:**

1. The system has potential for use in building and grounds security, law enforcement, and wild life research.

2. Requests for further information may be directed to:

Technology Utilization Officer  
Ames Research Center  
Moffett Field, California 94035  
Reference: TSP70-10638

**Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. D. Lee  
Ames Research Center  
(ARC-10097)

POTENTIAL TECHNOLOGY APPLICATION

Problem: TTU-5 CONTROL OF HIGH BLOOD PRESSURE BY  
BIOFEEDBACK TECHNIQUES

Institution: Texas Tech University  
Lubbock, Texas

Investigator: Ted Andreychuk, Ph.D.  
Psychology

Acquisition  
Date: May, 1973

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## PROBLEM OBJECTIVE

Researchers expressed the need for an automatic non-invasive blood pressure monitor for use in biofeedback studies with hypertensive patients.

## BACKGROUND

In the past decade it has been clearly demonstrated that activities, presumably controlled by the autonomic nervous system, can be influenced by operant conditioning techniques. As reviewed by Miller (1969) and DiCara (1970), early systematic studies of cardiovascular functioning have shown that heart rate and systolic blood pressure can be raised or lowered after only a few training sessions using biofeedback information. Most of the dramatic decreases in systolic blood pressure (lowered 25-35 mmHG) were accomplished using rats that were administered curare which leaves the voluntary muscular system inoperative.

However, recent studies by Shapiro, Tursky, and Schwartz (197) and Brener & Kleinman (1970) involving humans as experimental subjects have demonstrated that heart rate and systolic blood pressure can be controlled through operant conditioning techniques. Later studies have revealed that a significant degree of cardiovascular integration or differentiation of cardiovascular processes can be obtained using a reward system of monetary bonuses. That is, human subjects learned to increase or decrease systolic blood pressure with or without corresponding changes in heart rate when biosensory feedback was displayed and after being operantly reinforced.

An area of potential application of operant conditioning of the cardiovascular system is in the modification of symptoms in disorders mediated by the autonomic nervous system. For example, essential hypertension, in which the major symptom is an elevation of blood pressure without a demonstrable cause, is one



area of potential beneficial medical application. If high levels of blood pressure can be lowered permanently by means of instrumental training, this may constitute a significant adjunctive or alternative to other methods of treatment currently practiced that have detrimental side effects, such as pharmacological or surgical treatments.

The investigators propose to cover the following:

1. Compare the effectiveness of antihypertensive medications with operant conditioning techniques utilizing biofeedback information in lowering blood pressure in essential hypertensive subjects,
2. Investigate the importance of subject expectation by using a "placebo" control,
3. Assess the duration of treatment necessary to develop lower stable blood pressure levels,
4. Measure any post-treatment changes in manifest anxiety as expressed through psychological questionnaires, and,
5. Evaluate all interaction effects.

#### APPROACH

With the aims of the investigator in hand it was determined that a modification of the NASA/JSC developed Automatic Pressure Pump Programmer originally designed for the IMBLMS program might be feasible. Permission was obtained to utilize an existing prototype unit, and personnel at SwRI helped to outline a program of modifications for the unit to render it operable for their research program. The device is currently in work at JSC. It should be noted, the objective is not to provide an automatic cuff inflator, (these are commercially available), but to provide a research tool that can be programmed especially for operant training techniques to search out, measure, monitor and repeat process automatically for any blood pressure point desired.

POTENTIAL TECHNOLOGY APPLICATION

Problem: UAD-7 TELEMETRY OF ORAL pH FOR DETERMINATION  
OF LINKAGE TO CAVITY FORMATION

Institution: University of Alabama Medical Center  
Birmingham, Alabama

Investigator: Theodore Koulourides, D.M.D.  
Dental Research

Acquisition

Date: September, 1971

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PROBLEM OBJECTIVE

A microminiature telemetry device is needed to transmit oral pH to a nearby receiver.

BACKGROUND

Rather extensive work has been done in Switzerland (Graff and Muhlemann) on the use of pH radiotelemetry in the field of caries research. It has been observed microscopically that the glass electrodes being employed which had been exposed to the oral environment for as long as 13 days were completely covered with a slimy, yellowish material resembling oral debris. Some of this coating could be washed off. Histological examination of the remaining microbial aggregations revealed that all of the surrounding enamel areas, and most of the glass electrode sphere, were covered by a well structured, adherent, typical dental plaque. A layer of condensed streptococci was observable close to the enamel and sometimes also to the peripheral parts of the glass electrode. However, some islands at the pole of the pH electrode were free of microbial deposits. It was concluded that the pH indicated by the glass electrode probably originated not only at the glass electrode/plaque interface, but was also influenced by the hydrogen ion concentration of interdental fluid, which, through loose non-adherent microbial masses has direct access to the small electrode areas still uncoated by adherent plaque. In other unpublished reports, it has been observed that the proper functioning of the glass electrode is impaired when totally covered by microbial populations not removable with a stream of water.

pH radiotelemetry has been established to determine the link between dietary habits and cavity formation. The process has been successful enough to have been declared as a mandatory

test by the Swiss Federal Health Authorities for the quantification of carbohydrate-containing products such as sweets, chewing gum and chocolate. These products can only be claimed to be "safe for teeth" if, during testing, the pH does not drop below the 5.7 level.

The investigator is extremely interested in carrying on this research in the United States and approached NASA for both technological and fabrication capabilities. The problem has been researched, and from the standpoint of the telemetry, there is essentially no problem.

It is almost vital that a new pH sensor be developed, one that would not be subject to the malfunction of the glass electrodes described in the Swiss studies. Because the sensor must remain in the oral cavity for extended periods of time, the investigator has specified both the sensor and transmitter must fit within the confines of a 2 cm<sup>2</sup> dental bridge.

From suggestions from NASA/Ames, the team has been directed to Dr. Wen H. Ko of Case Western Reserve, working under NASA contract for miniature pO<sub>2</sub> sensor. His associates have been more than helpful in promising more details on their recent work on miniature pH and related enzyme sensors. It may be that the team cannot carry this potential application through NASA technology completely, but it is generally felt that efforts to continue implementation should continue.

POTENTIAL TECHNOLOGY APPLICATION

Problem: UAM-14 SELF-PROPELLED METABOLIC ANALYZER CART

Institution: University of Alabama  
Spain Rehabilitation Center  
Birmingham, Alabama

Investigator: George H. Traugh

Acquisition  
Date: January, 1972

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## PROBLEM OBJECTIVE

Investigators outlined a need to develop a portable, speed controlled metabolic analyzer to measure energy expenditure, CO<sub>2</sub> production, N<sub>2</sub> metabolism, cardio-respiratory responses in a multiple of activities, such as ambulation, exercise, transfers or stationary work.

## BACKGROUND AND APPROACH

Studies of energy consumption during ambulation have used the traditional treadmill with the exception of a few studies performed using the Speed Controlled Respirometer for Ambulation Measurement (SCRAM) described by Corcoran, P. J. in the Archives of Physical Medicine and Rehabilitation, 51: 78-87, 1970.

The treadmill cannot be used with patients who have a severe gait impairment due to the difficulty of ambulating on a treadmill. Ambulation on a stationary surface is more normal physiologically. Therefore, a method of measuring energy expenditure during actual ambulation is necessary for more accurate studies which could include the severely impaired.

The Mobile Automatic Metabolic Analyzer (MAMA) is a metabolic analyzer, similar to the one used in the Skylab program, mounted on an electric cart. Developmental work is being carried on at Marshall Space Flight Center in conjunction with the investigators. The cart can follow a track at a constant speed while a patient under test ambulates with it. Within the MAMA vehicle is housed the metabolic analyzer package, a Perkin-Elmer Gas Analyzer, a recorder, a 60 Hz inverter, three 12-volt batteries, three battery chargers, and all the vehicle drive electronics.

The MAMA vehicle has several unique features in the steering, drive and braking systems. MAMA uses single wheel steering; the left front wheel is driven by an electric motor and the right front wheel is castered to follow. This type of steering permits the vehicle to have a tight turning radius (about 4 feet) which is necessary for maneuvering inside hospitals. The steering motor is driven with an amplifier that is controlled either from a model aircraft joystick or an optical tracker.

The optical tracker is used when the vehicle is in the automatic mode to sense a white stripe on a black tape. The optical tracker can determine when it is on the tape and will let the vehicle run only when it sense both black and white stripes. For any other color pattern, the tracker will command the vehicle to stop. This feature permits the doctor to set the distance of any test run by simply placing a piece of uniform material across the track.

MAMA is powered by two dc torque motors. Each motor drives a rear wheel through a chain on sprocket drive and can be controlled in the manual mode by a joystick and in the automatic mode by a dial potentiometer. The motors are driven by separated power amplifiers that are designed to command a torque in the motor as a function of input voltage. This means that for any given input voltage, the motors will develop a constant torque on any speed, and when the amplifier inputs are driven from the same source, the rear wheels behave as though driven through a mechanical differential.

The drive motors each have a tachometer that is used to control the speed of the vehicle. Since only one input controls motor speed, the output of the two tachometers can be summed or differenced to generate speed reference points along a line through the axis of the driven wheels. By proper switch selection, MAMA's speed can be referenced with respect to the left wheel, right wheel, center of the cart or the position where the patient is ambulating. When the speed is referenced to the patient, the cart will adjust speed so that the patient walks at a constant rate even when the cart is going around curves.

Most important to MAMA operation is safety, and safety is the braking system. MAMA has both dynamic brakes and band brakes. In normal operation, dynamic braking is used to control cart speed and bring it to a stop. In the automatic mode the band brakes are applied and the drive motor electronics are turned off after the cart has come to a normal stop. When an emergency develops, such as a patient falls or the cart strikes an object, the band brakes are applied instantaneously and the drive motor amplifiers are turned off. In addition to this, the doctor has

a hand held push button switch that will also stop the vehicle.

MAMA has been designed with consideration for both the doctor and the patient. The vehicle is automatic during test runs to free the doctor to work with the patient, it is quiet and has a pleasant appearance so not to frighten the patient. Also it is functional. The doctor can command any speed between zero and six mph within  $\pm 1\%$ . The speed can be referenced to the path that the patient is walking and not the vehicle and the speed is constant up and down grades of up to 8%. The acceleration can be set over a range of 1 to 3 feet per second. Safety has not been overlooked; the vehicle will stop when the doctor commands it, when sensor leaves the track, when vehicle hits an object, when the patient falls down or when there is an electronic failure.

The metabolic analyzer measures the following: inspired volume, expired volume,  $\%O_2$ ,  $\%CO_2$ ,  $\%N_2$ , and  $\%H_2O$ . These measured quantities are then used by the computational electronics to give volume of  $O_2$  consumed and volume of  $CO_2$  produced for each breath.

The system consists of two spirometers, a gas analyzer, computational electronics, and data handling electronics. The subject breathes from an inhale spirometer and into an exhale spirometer. The subject will wear a suitable face mask which contains valves to route the inhaled breaths to the proper spirometer. A moisture trap is installed in the exhale line to trap most of the water from the breath. The gas analyzer sample inlet is placed at the outlet of the expiration spirometer and measures the % of  $O_2$ ,  $CO_2$ ,  $N_2$ , and  $H_2O$ . Each spirometer consists of a moving piston. The piston is connected to a potentiometer which gives a voltage out which is proportional to volume.

The computational electronics receives signals from the spirometer volume potentiometers and also feeds signals to valves at the output of each spirometer. Each spirometer also has a microswitch to sense when the spirometer is fully returned to the starting position.

The subject inhales from the inspiration spirometer. This spirometer then remains at the final position and the voltage proportional to inspired volume is stored in the computational electronics. When the subject starts to exhale into the expiration spirometer, the electronics sense the motion of the expiration spirometer, and send a signal to the inspiration spirometer inlet valve allowing the inspiration spirometer to return to the starting position. As the subject starts to inhale, the electronics sense the motion of the inspiration spirometer and send a signal to allow the expiration spirometer to return to the starting position. The values from the gas

analyzer are fed to the computational electronics and along with the volumes are used to calculate the volume of  $O_2$  consumed and  $CO_2$  produced for each complete breath. The % of  $N_2$  and  $H_2O$  in each exhaled breath is also fed to the data electronics.

The data electronics receives voltages proportional to: inspired volume, expired volume, volume of  $O_2$  consumed, volume of  $CO_2$  produced, % $N_2$  and %  $H_2O$ . In addition, a signal coded to signify start and stop of the cart and time is fed to the data system. The data system multiplexes or samples each input and converts the voltage of a 10-bit binary number. This 10-bit number is then added to five other bits for identification and serialized. The serial train of bits is then encoded for storage on a cassette tape recorder. All seven words are recorded every 1/10 of a second.

Electronics will also be supplied to decode and convert the binary data to a series of 15-bit parallel binary words for use by the computer. The computer can then sample, as often as desired, to give averages of  $O_2$  consumed,  $CO_2$  produced, etc.

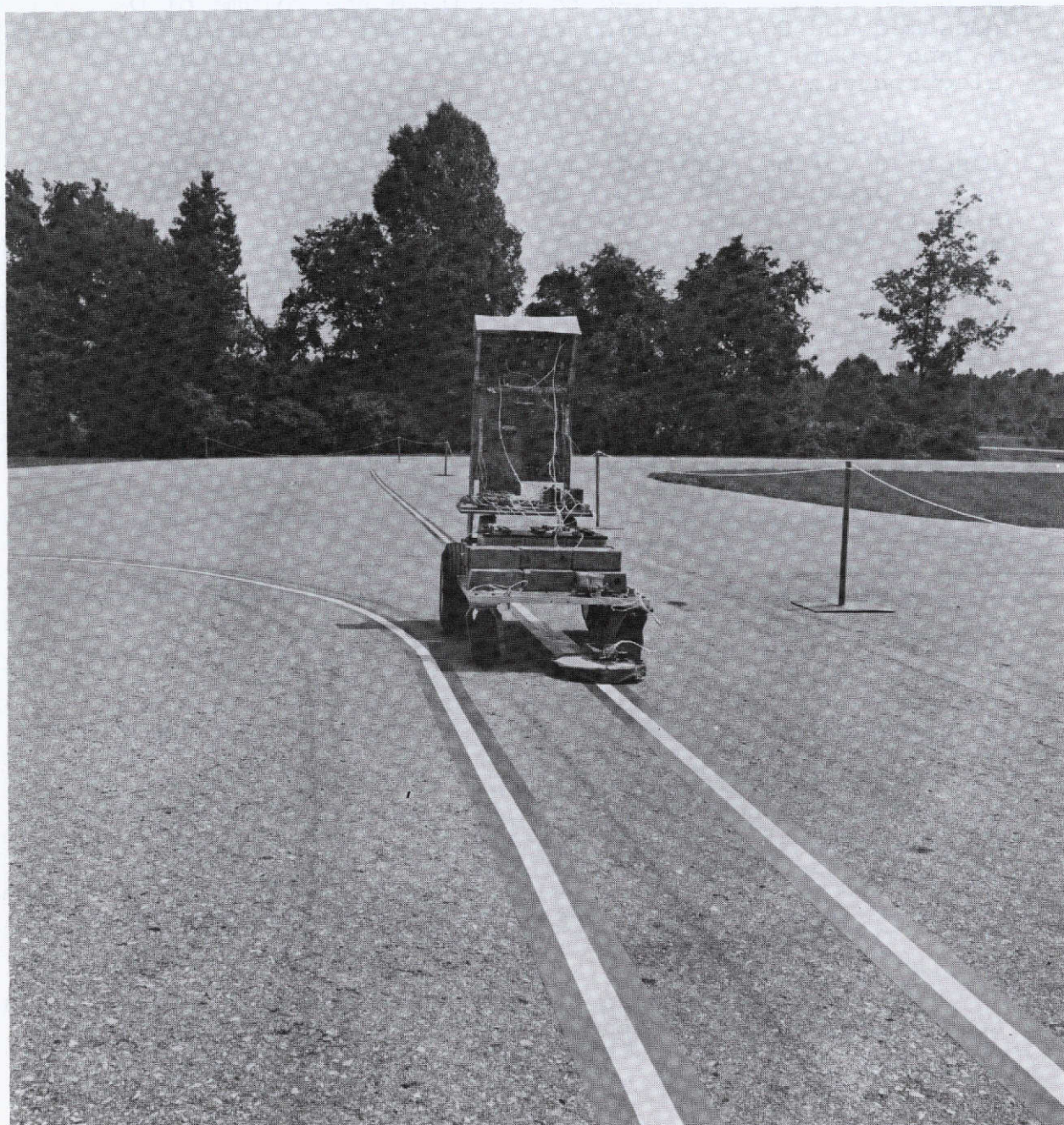
A separate system is used to monitor the subject's heart activity. This system consists of EKG electrodes and a sensitive amplifier. The output of the amplifier is used to modulate a carrier frequency for recording on the cassette tape recorder. The tape output is demodulated to recover the heart beat waveform and by use of the time reference to give heart rate.

The electronics are all solid state and are built on printed wiring boards to facilitate easy removal for repair in the event of a component failure.

-----from University of Alabama  
Spain Rehabilitation Center Annual  
Report, 1973, pp. A-173-182.

MSFC is presently in final stages of completion and hopes to deliver the unit to the investigator in October, 1973.

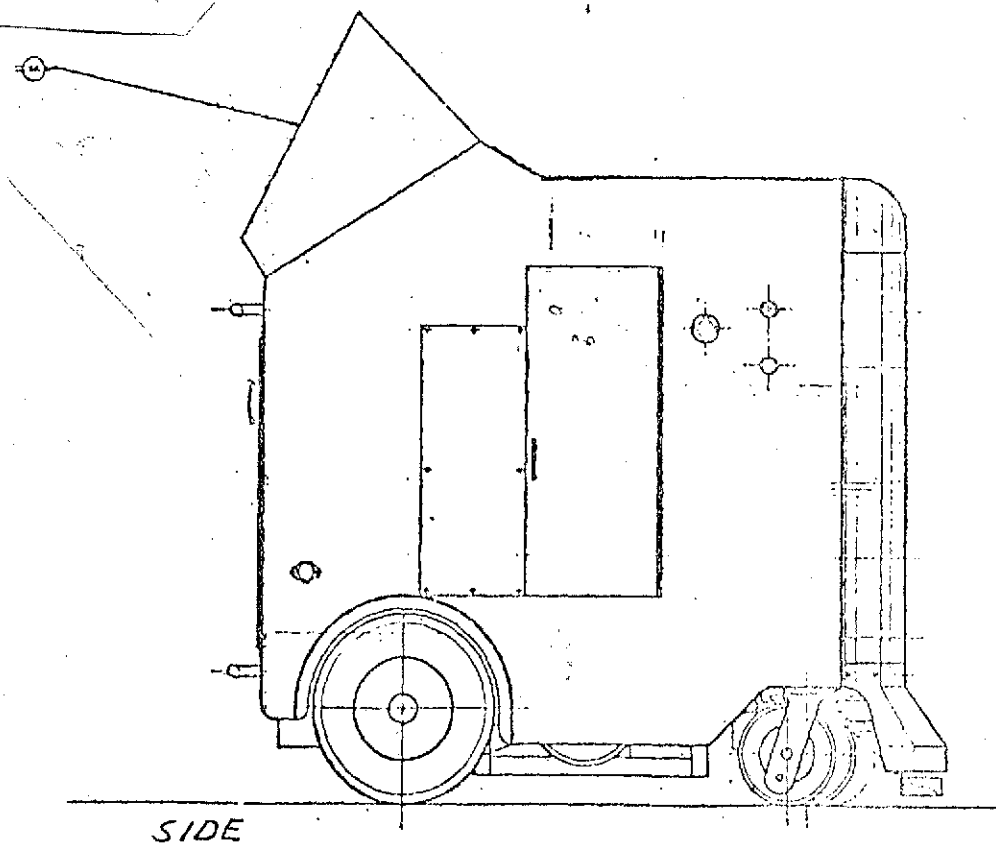
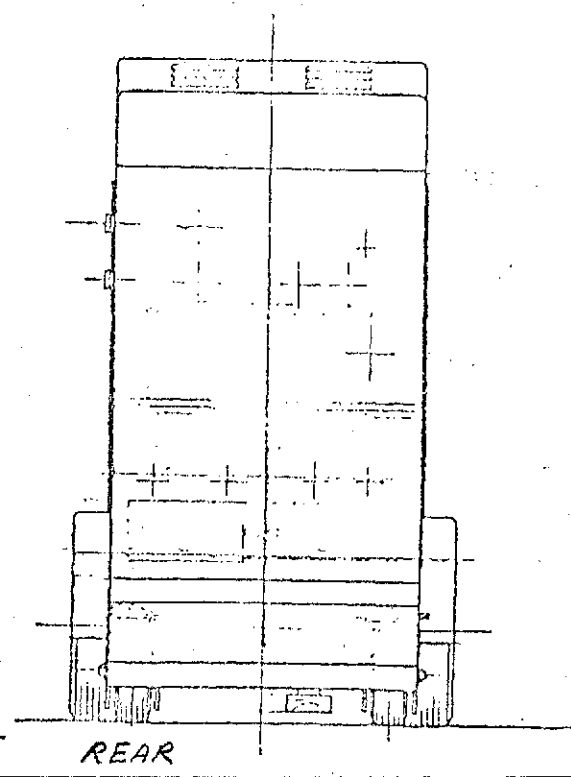
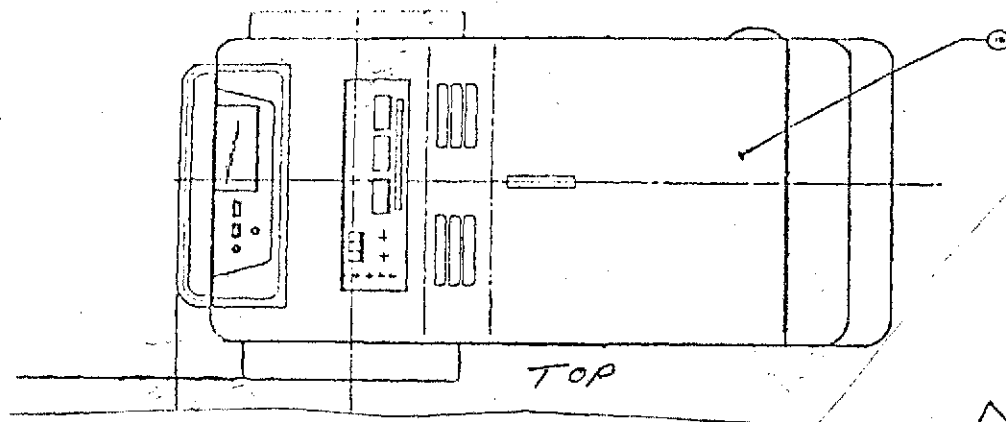




UAM-14 Mobile Automatic Metabolic Analyzer

(A prototype model on a test track  
at the developmental site-  
Marshall Space Flight Center)





Skin Design of the Total Mobile Automatic Metabolic Analyzer

POTENTIAL TECHNOLOGY APPLICATION

Problem: UTM-38 IMPROVED URETHRAL VALVE FOR  
NONSURGICAL IMPLANTATION

Institution: University of Utah  
Salt Lake City, Utah

Investigator: Clifford Kwan-Gett, M.D.

Acquisition  
Date: March, 1972

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PROBLEM OBJECTIVE

The need was stated for a biocompatible, implantable urethral valve to control the flow of urine from incontinent patients.

BACKGROUND AND APPROACH

Loss of voluntary control of urinary bladder function is common to many kinds of disease and injury cases. The dysfunction manifests itself in two ways, loss of urethral sphincter function and bladder or sphincter spasticity. The condition is treated by use of a urethral or super-pubic catheter to drain the bladder or hold the sphincter open. Among those problems which arise either from the incontinence or the catheterization are kidney infections, patient embarrassment and inconvenience, interference with sexual function, and over-use of patient-care personnel.

Surgically-implantable urethral valves have been developed and tried by the RTI BATEam and by non-NASA programs. Among other problems, however, is the fact that urinary function control does not return in some patients, and existing surgical alterations are irreversible. What is needed is an insertable/removable device to control bladder emptying.

A design concept has been presented by the investigator which promises to alleviate the problem. The concept involves a silastic encased metal valve which could be non-surgically inserted up the urethra to mechanically hold open the urethral sphincter. The valve conceptually could be removed occasionally for inspection, cleaning, cystoscopy, or voluntary bladder control training. Further, the concept is simple enough to be feasible for frequent discarding and replacement, if desired.

Functionally, the valve would open under sudden pressure increase as could be brought on by hand-pressure directly on the bladder area of the lower abdomen. The valve would thus open and remain open under flow conditions, then self-close when internal and external pressures reach equilibrium.

The SwRI BATEam has completed preliminary prototype engineering drawings and is now working on materials development. Perhaps a material such as is described in NASA Tech Brief B72-10301 (copy follows summary) would help both in structural design and possible biocompatibility and wear problems. Preliminary designs are not included in this report until prototype work can be initiated.

The investigator has stated he will willingly test the device in experimental animals and share the results with the medical community through publications. Discussions of the concept with leading rehabilitation personnel have enjoyed enthusiastic interest and hope.

# NASA TECH BRIEF

*Ames Research Center*



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## Protective Encapsulation of Implantable Biotelemetry Units

### The problem:

Electronic components are usually protected from the environment by thin coatings of paint, polymers, waxes, etc., but special coatings must be used to protect body-implantable biotelemetry units which consist of electronic telemetry circuits, batteries, and electromagnetic radiators. The problem of providing adequate protection for body-implantable telemetry units is complicated by the highly penetrating and corrosive nature of animal body fluids and by the need for electromagnetic radiators to be electrically unshielded.

### How it's done:

An encapsulation method which uses one or more layers of poly(*p*-xylylene) in conjunction with a material such as silicone rubber so as to take advantage of the properties of both materials.

### The solution:

The component parts of the device are interconnected electrically and then protected with conventional prior-art devices such as metal or ceramic packages with metal-to-glass connection feed-through seals. The assembled device, attached to the electromagnetic radiator, is then coated with an encapsulating layer of silicone rubber to provide mechanical support and protection and also to form a body-compatible surface contour. A layer of poly(*p*-xylylene) is then deposited on the silicone rubber and then another layer of silicone rubber is subsequently applied over the poly(*p*-xylylene). As many alternating coats of

silicone rubber and poly(*p*-xylylene) can be applied as is considered desirable. The method of encapsulation utilizes the favorable properties of silicone rubber in animal fluids with the chemical inertness of poly(*p*-xylylene) and its resistance to penetration. Because the layer of poly(*p*-xylylene) is sandwiched between silicone rubber, it is protected from mechanical damage, but the outer surface of the capsule retains the desirable characteristics of silicone rubber when immersed in body fluids.

### Notes:

1. Various types of poly(*p*-xylylene) can be used so as to emphasize preferred characteristics. The polymer can be applied over the components prior to application of the first layer of silicone rubber. An adhesive promoter may be applied under, over, or on both sides of a layer of poly(*p*-xylylene).
2. Other materials can be substituted for the silicone rubber.
3. No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer  
Ames Research Center  
Moffett Field, California 94035  
Reference: B72-10301

### Patent status:

No patent action is contemplated by NASA.

Source: Nigel C. Tombs and Jack M. Pope  
Ames Research Center  
(ARC-10514)

Category 04, 05

### POTENTIAL TECHNOLOGY APPLICATION

Problem: UTM-39 MULTI-CHANNELED HYPOTHERMIA BLANKET  
FOR HEART SURGERY

Institution: University of Utah  
Salt Lake City, Utah

Investigator: Clifford Kwan-Gett, M.D.

Acquisition  
Date: November, 1972

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#### PROBLEM OBJECTIVE

Investigator asked for design and materials technology to develop a plastic envelope containing a convoluted channel for passage of chilled water to be used during surgery with hypothermia to encircle the exposed heart organ.

#### BACKGROUND

It has been accepted by surgeons in heart surgery that heart muscle tissue survives for prolonged period at reduced temperatures during extra-corporeal (or heart bypass) circulation assisted surgery. Present technique involves constant bathing of the exposed organ with chilled water and attendant syphoning off of the spilled fluid from the opened pericardial cavity. The proposed surgical device could enshroud the heart in a chilled blanket, yet offer the advantages of a closed water system.

The material chosen should remain flexible at temperatures near 0°C. A familiar grade of vinyl or other plastic would allow modification with scalpel and surgical tools, as well as needed sterilization. The proposed device would not only clean up the present technique, but would free at least one surgical assistant.

#### APPROACH

A rough prototype "blanket" device has been fabricated of a heat-sealed vinyl envelope and sent to the investigator for evaluation. He reported that the configuration was satisfactory, but that the envelope developed a leak and was not useful for further trial.

It is suggested that a sealed terminal device could be designed and fabricated, using food-packaging techniques devised by NASA, to be used in conjunction with proposed cooling equipment discussed in problem MSC-1.

### 2.3 Biomedical Community Impacts

Below is a list of those biomedical problems for which a technology impact has been claimed during the period covered by this report. An impact is defined as information, method, or source provided to a problem originator that resulted in his changing his activities in a way that enhances his progress toward a medical objective but did not sufficiently involve implementation or adoption of specific aerospace technology. On the following pages are reports for those impacts claimed.

No.	Problem Title	Date Opened/Closed
LVA-8	Abrasive-Resistant Plastic Material for Use in Trace Element Research Studies	09-72/06-73
MHH-1	Rapid Identification of Surgical Instruments	06-72/05-73
TCB-18	Permanent Reflective Coating for Use on Canes for the Blind	04-72/05-73

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BIOMEDICAL COMMUNITY IMPACT

Problem: LVA-8 ABRASIVE RESISTANT PLASTIC MATERIAL FOR  
USE IN TRACE ELEMENT RESEARCH STUDIES

Institution: Veterans Administration Hospital  
5901 East Seventh Street  
Long Beach, California 90801

Investigator: David B. Milne, Ph.D.

Acquisition Date: September, 1972 Completion Date: May, 1973

PROBLEM OBJECTIVE

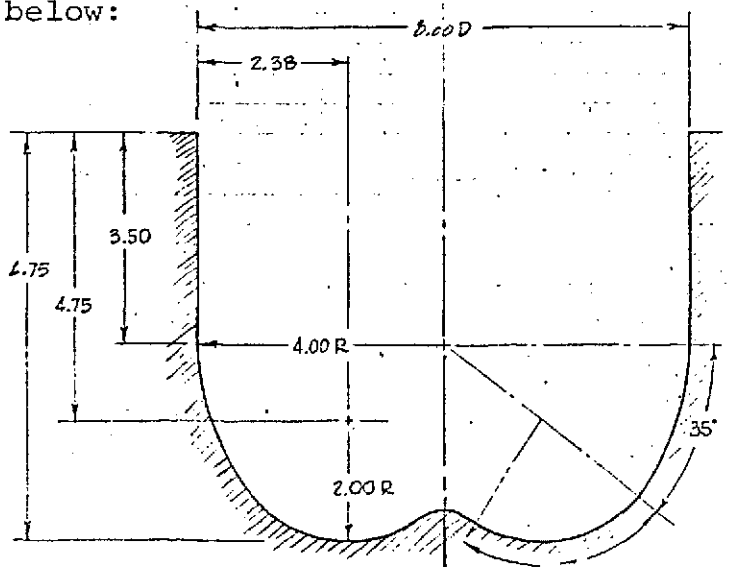
Investigator needed to identify a highly abrasive-resistant plastic material, low in trace metal content, for use as diet mixing bowls in trace element studies.

BACKGROUND

Investigator was conducting extensive basic research involving the significance of various trace metals on metabolism. In the program, highly purified diets had to be mixed while keeping contaminants from metallic elements and silicon to an absolute minimum. Difficulties were being experienced, since available mixing bowls are made of either glass or stainless steel.

RESOLUTION

The needed bowls had to fit into the Hobart mixing systems in use at the hospital. A drawing of the bowl shape appears below:



NOTE: DIMENSIONS SHOWN  
ARE INTERNAL ONLY.  
WALL THICKNESS IS  
MATERIAL DEPENDENT.

MIXING BOWL,  
ABRASION RESISTANT  
(PROBLEM LVA-8)

C. W. FARLAND 4-10-72

Through the help of Warren Kelliher at Langley Research Center, we received information on a commercially available plastic that appeared to meet the desired requirements:

Material: PACTENE (a super-high molecular weight compression molded polyethylene)

Characteristics applicable to solution:

1. High abrasive resistance (has work-hardening characteristic under load or repeated impact.)
2. Water absorption nil.
3. Non toxic.
4. Can be milled into bowl shape.
5. Can be sterilized (resists all alkalies and all but concentrated nitric and sulphuric acids.)
6. Contains no metal elements or silicon.
7. Chemical formula: 
$$\begin{array}{c} \text{H H H} \\ | | | \\ -\text{C}-\text{C}-\text{C}- \\ | | | \\ \text{H H H} \end{array}_n$$

Available from: Schmidt Industries  
133 Court Street (P.O. Box A-995)  
New Bedford, Massachusetts 02741

Special engineering requests to:

Poly-Hi Engineering  
596 Orchard Street  
New Bedford, Massachusetts 02741

EVALUATION:

Because of its non-NASA technology, the solution could not be carried further under the BATEam program. However, investigator was enthusiastic about the material specifications. Poly-Hi Engineering agreed to take on the novel application through a proposal presentation, but prototype R&D costs must be funded. It has also been suggested that the "Pactene" could be used to mold the mixing element beater or blender configuration for as complete as possible trace element control.



BIOMEDICAL COMMUNITY IMPACT

Problem: MHH-1 RAPID IDENTIFICATION OF SURGICAL  
INSTRUMENTS

Institution: Methodist Hospital  
Houston, Texas

Investigator: Mrs. Newcomb, R.N., Surgical Nurse

Acquisition Date: June, 1972 Completion Date: May, 1973

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## PROBLEM OBJECTIVE

Investigator needed a means of identifying surgical instruments quickly as they are removed from sterilization units.

## BACKGROUND

All surgical instruments are sterilized centrally in large hospitals. Physicians prefer to have individual sets of instruments. Personnel cannot or will not take the time to meticulously examine each instrument or identify same. Etching was undesirable, and a means of color coding was natural. Investigators tried different tapes but they did not hold up under cleaning. Teflon coatings flaked and vegetable paint did not hold up under ultrasonic cleaning.

## RESOLUTION

After failing to locate an effective solution in NASA Technology sources, a search of commercially available materials produced the following solution:

Material: 3M Vinyl Film Tape (Colors available: Transparent, Yellow, White, Black, Red, Blue, Green, Orange, Brown, and Red-Orange) Stock No. 471.

Also: 3M Polyester Film Tape (Colors available: Transparent, Red, White, Black, Gold, Silver) Stock No. 850

Both tapes hold up extremely well for all required cleaning:

1. Ethylene Oxide Sterilization
2. Autoclave at 278° at 30 psi
3. Ultrasonic cleaning

The vinyl film tape was best, and with the wide range of colors, sufficient color coding can be achieved. Investigator has been provided with the information and is satisfied with the results.

This solution was a relatively simple one, but it represented a real "problem" in daily activities. It is feasible that this tape could be used in wider applications where color coding would be useful, especially where aseptic conditions must be maintained.

BIOMEDICAL COMMUNITY IMPACTS

Problem: TCB-18 PERMANENT REFLECTIVE COATING FOR  
CANES FOR THE BLIND

Institution: Texas Commission for the Blind  
Criss Cole Rehabilitation Center  
4800 Lamar Blvd.  
Austin, Texas 78757

Investigator: Nick Necaise  
Director of Mobility Training

Acquisition Date: April, 1972 Completion Date: May, 1973

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## PROBLEM OBJECTIVE

Investigator needed a material or method that would provide a permanent and scratchless reflective coating for aluminum canes for the blind so that traffic could safely see a blind person at night if he were walking or crossing streets.

## BACKGROUND

Commercial reflective tape has been used, but the surface becomes easily scratched and the tape strips off after only minimum wear. Investigator preferred to utilize the aluminum canes already in existence and wished for a cosmetically pleasing coating. A NASA data bank search was performed, but all coatings were too heavy (would upset cane touch balance) and most required extensive preparation and curing and were rather expensive.

## RESOLUTION

At a suggestion from Wayne Chen at Goddard, we tried the use of a white epoxy base paint imbedded with plastic beads. The technique was applied and canes were tested over a four month period for wear. They neither chipped nor lost their reflective capacity. And the plastic beads are smooth enough to be tactually pleasing.

Material: (1) Any good quality epoxy base white paint, and  
(2) polyester beads (40-100 mesh).

Material available from: Koppers Company, Inc.  
440 College Park Drive  
Monroeville, Pennsylvania 15148  
Attn: John McNally

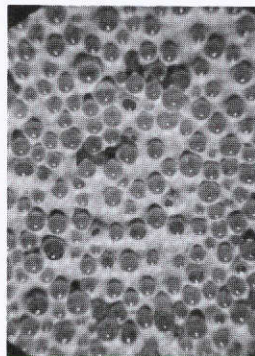
Note: Polyester beads were used instead of PVC beads because of their superior wear capability (comparable to glass, but far smoother and abrasive resistant)

Technique for application: Cane is prepared by brush etching the cane surface, either by coarse sandpaper or metallic brush sanding. After all particles are removed, paint is applied evenly and fairly heavily, preferably by spraying. Beads can then be dropped onto the painted surface like glitter and the excess allowed to drop off, or if the pressure is light enough (so as not to completely 'sink' the beads) the painted cane can be rolled in the beads. Cane should be sufficiently set for use within 24 hours with no special curing.

Canes coated in this manner are extremely cost effective, are cosmetically pleasing (they remain bright white with a textured finish by day, and at night they reflect light just like highway traffic signs...from whence the original idea was derived.)

#### EVALUATION

The investigator was pleased with the initial wear studies on samples we coated for him. He has been provided with a supply of polyester beads with application instructions for his use.



15X Magnification of Polyester Beads  
Embedded in a Paint Substrate  
(Photo Courtesy of SwRI Automotive Research)

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## 3.0 SUMMARY OF TEAM ACTIVITY DURING THE REPORTING PERIOD

3.1 Problems in Progress at Contract Termination  
(by Institution)ARKANSAS ENTERPRISES FOR THE BLIND, Little Rock, Arkansas

AEB-5 Motion Sensor to Provide Biofeedback to  
Blind Persons Unaware of Involuntary  
Movements

CALLIER HEARING AND SPEECH CENTER, Dallas, Texas

CHS-10 Hearing Aid Malfunction Alarm System

CHILDREN'S CONVALESCENT HOSPITAL, Oklahoma City, Oklahoma

OCH-5 Failure Resistant Cerebrospinal Fluid Shunt

OCH-6 Sensory Hemiplegiac Stimulator

CRAIG REHABILITATION HOSPITAL, Englewood, Colorado

CRH-1 Differentially Inflated Segmented Seat  
Cushion

CRH-2 Low-Friction, Porus Material for Orthopedic  
Collar

CRH-4 Portable, Compact Breathing Machine

CRH-5 Improved Clamp for Urine Collection Device

CRH-7 Joy-Stick Control for Automobile

GENERAL ROSE HOSPITAL, Denver, Colorado

ROS-2 Method for Measuring Blood Gas Non-Invasively

LOUISIANA STATE UNIVERSITY MEDICAL CENTER, New Orleans, La.

MSC-1 Portable Scalp Cooling Device (Chemotherapy)

M.D. ANDERSON HOSPITAL, Houston, Texas

MDA-1 Radiation Resistant Tilt Table for Use in  
Radiotherapy

PACIFIC STATE HOSPITAL, Pomona, California

PSH-1      Portable Patient Alcohol Level Indicator

RANCHO LOS AMIGOS HOSPITAL, Downey, CaliforniaRNV-40      A Rigid Lightweight Structure for a Damped  
OrthosisSCOTT & WHITE CLINIC, Temple, Texas

SWC-2      Cortical Audiometry Measurements

TEXAS COMMISSION FOR THE BLIND, Austin, TexasTCB-20      Device to Enable Blind Diabetics to  
Self-Assess Urinalysis TestsTEXAS COMMISSION FOR THE DEAF, Austin, TexasTCD-4      Noise-Activated Flasher Warning Device  
for Deaf DriverTEXAS TECH UNIVERSITY, Lubbock, TexasTTU-1      Automated Stimulus/Response/Record Device  
for Behavior Modification of the Profoundly  
Retarded.

TTU-3      Rate Monitor for Self-Injurious Behavior

TTU-4      Nocturnal Activity Monitor

TTU-5      Control of High Blood Pressure by Biofeedback  
TechniquesUNIVERSITY OF ALABAMA DENTAL RESEARCH, Birmingham, AlabamaUAD-7      Telemetry of Oral pH for Determination of  
Linkage to Cavity FormationUNIVERSITY OF ALABAMA MEDICAL CENTER, Birmingham, Alabama

UAM-14      Self-Propelled Metabolic Analyzer Cart

UAM-19      Method for Early Detection of Metabolic  
Changes During the Dying Process of Infants  
in ICU Units

UNIVERSITY OF CALIFORNIA AT SAN DIEGO, La Jolla, California

- SDU-1 Complete Portable System for Acquiring and  
Analyzing Audio Evoked Responses

UNIVERSITY OF IOWA MEDICAL SCHOOL, Iowa City, Iowa

- IOU-1 Method for Measurement of the Amount of  
Humidity Present in the Lower Respiratory  
Tract

UNIVERSITY OF KENTUCKY MEDICAL SCHOOL, Lexington, Kentucky

- UKM-1 Implantable Antenna for Mandible Healing  
Studies
- UKM-2 Respiration Rate Measurement of Experimental  
Animals During Vibration Experiments
- UKM-3 Improved Technique for Measuring Blood Flow  
Velocity in Very Small Vessels In Situ

UNIVERSITY OF SOUTHERN CALIFORNIA MEDICAL SCHOOL, Los Angeles

- USC-13 Detection and Reactivation of Dormant Cells  
in Inner Ear
- USC-14 Chemical Diets for Surgical Patients and  
Allergy Studies

UNIVERSITY OF TEXAS MEDICAL SCHOOL, Galveston, Texas

- GLM-35 Beta Radiation Catheter Probe
- GLM-45 Improved Stretcher Design and Materials  
for Burn Patients
- GLM-51 Pressure Telemetry Alarm for Hydrocephalics
- GLM-52 Leukocyte Response to Plastic Particles

UNIVERSITY OF UTAH, Salt Lake City, Utah

- UTM-38 Improved Urethral Valve for Nonsurgical  
Implantation
- UTM-39 Multi-Channeled Hypothermia Blanket for  
Heart Surgery
- UTM-41 Measurement of Thrombus Adhesion to Blood  
Vessel Wall
- UTM-42 Composites for Internal Biocompatible  
Prostheses

UTM-43      Techniques for Characterizing Surface  
             Roughness under Electron Micrography

UNIVERSITY OF WISCONSIN MEDICAL COLLEGE, Milwaukee, Wisconsin

WMC-2      Identification of Korotkoff Diastolic Point

WMC-3      Optimum Methodology for Analyzing  
             Cardiovascular Data

VETERANS ADMINISTRATION HOSPITAL, Birmingham, Alabama

AVA-2      Carotid Artery Pressure Waveform Measurement

VETERANS ADMINISTRATION HOSPITAL, Little Rock, Arkansas

VAL-1      Inexpensive Portable Instrumentation Tape  
             Recorder for Electrogoniometric Studies

VAL-2      Animal Activity Sensor

VETERANS ADMINISTRATION HOSPITAL, Oklahoma City, Oklahoma

OVA-2      Measurement of Lung Compliance



No.	Problem Title	Opened/Closed	Remarks
AEB-1	Method for Identifying Denominations of Paper Money	06-72/03-73	Hardware Tech. Appl.
AEB-2	Measurement of Physiologic Stress Parameters	06-72/01-73	Hardware Tech. Appl.
AEB-3	Light Sensitive Vocational Rehabilitation Aid	06-72/09-73	Hardware Tech. Appl.
AEB-4	Apparatus for Measuring Tactile Spatial Separation	06-72/09-73	Hardware Tech. Appl.
AEB-6	Arc/Angle Measurement of Travel of Cane for the Blind	02-73/06-73	Low Priority
BLM-10	Computer Programs & Systems for Analysis of the ECG	06-69/11-72	Insufficient Progress
BLM-13	Nonthrombogenic Material for Use as a Blood Interface	09-69/11-72	Solution Commercially Available
BLM-17	Improved Procedures to Measure Regional Blood Flow in Kidney	02-70/02-73	Insufficient Progress
BLM-25	Simple Economical Mass Screening Techniques for Analysis of ECG in Clinical Diagnosis & Multiphasic Health Screening	04-70/11-72	Insufficient Progress
BMC-1	Attraction-Movement of Non-Magnetic Material	01-71/11-72	Insufficient Progress
BMC-4	Improved Arch Support Matl.	10-71/03-73	Insufficient Progress
BMC-6	Biofeedback Training of Experimental Subjects	10-72/01-73	Solution Commercially Available
BMC-7	Automatic Device for Administering Visual Field Tests to Glaucoma Patients	01-73/06-73	Solution Identified-Problem Originator not able to evaluate
BMC-8	Self-Generating Oxygen Supply	01-73/09-73	Investigator changed personnel & interest
BVA-1	X-Ray Transparent Electrodes and Leads	05-70/09-73	Hardware Tech. Appl.
BVA-4	Portable ECG Telemetry Receiver and Tape Recorder	04-70/01-73	Hardware Tech. Appl.
BUD-1	Heat & Stress Resistant, High Strength Plastic for Fabrication of Orthotic Devices	07-71/09-73	Insufficient Progress
CHS-3	Multiple Electrode Stimulation of the Cochlea	02-71/11-72	No Applicable NASA Technology

No.	Problem Title	Opened/Closed	Remarks
CHS-5	Flexible Interface with Auditory Brain Centers	01-71/11-72	No Applicable NASA Technology
CHS-7	Auditory Center Brain Implant Electrodes	01-71/11-72	Solution Cost Beyond BATEam Resources
CHS-11	Artificial Eye Lens	01-71/11-72	Solution Cost Beyond BATEam Resources
CHS-12	Dipole System for Auditory Multichanneled Stimulation of the Brain	02-71/11-72	No Applicable NASA Technology
CHS-14	Magnetic Stimulator for Deaf-Blind Patients	08-71/11-72	No Applicable NASA Technology
CLA-3	Alarm Circuitry for Apnea Telemetry	09-71/11-72	Tech. Appl. Evaluation Completed
CPT-1	Head Control Conditioning and/or Teaching Methods for Athetoids	10-72/12-72	Conflicts with ongoing non-NASA Technology
CRH-3	Means to Minimize Venous Pooling	12-72/05-73	No Applicable NASA Technology
CRH-6	Urine Collection Device for Incontinent Females	12-72/05-73	No Applicable NASA Technology
CRH-8	Weight Shift Alarm for Brain Damaged & Paraplegic Persons	03-73/07-73	Hardware Tech. Appl.
DLM-14	Detection of Kidney Stones during Surgery	04-70/02-73	Insufficient Progress
FTZ-1	On-Line Breath Analyzer	12-70/08-73	Information Tech. Appl.
FTZ-2	Invasive Means for Measuring Blood Gases	12-70/12-72	Solution Commercially Available
GLM-5	Intracranial Pressure Telemetry System	05-67-10-72	Hardware Tech. Appl.
GLM-32	ECG Preamplifier for Home Tape Recorder	04-70/08-73	Hardware Tech. Appl.
GLM-37	Activity Telemetry from Single Neurons in Aquatic Animals	10-70/11-72	Not biomedically oriented
GLM-39	Artificial Speech Synthesizer	08-71/01-73	Solution Cost Beyond BATEam Resources
GLM-40	Telemetry from Divers	08-71/01-73	Insufficient Progress

No.	Problem Title	Opened/Closed	Remarks
GLM-41	Electrodes to Measure Potentials of the Cochlea and VIII Nerve Action	02-71/11-72	No Applicable NASA Technology
GLM-42	Automatic Interruptor of Speech to Separate Words by Phonemes During Tape Recordings	02-72-11-72	Solution Cost Beyond BATEam Resources
GLM-43	Quick Attachment/Release Clamp	09-72/02-73	Incorporated into GLM-45
GLM-44	Quickly Adjustable Crutch	09-72/06-73	Hardware Tech. Appl.
GLM-46	Adjustable Cradle to Cover Burn Patients	09-72/06-73	Hardware Tech. Appl.
GLM-47	Improved Stretcher Design	09-72/06-73	Incorporated into GLM-45
GLM-48	Ceiling Attachments in Hydrotherapy Room	09-72/12-72	Solution Commercially Available
GLM-49	Monorail Patient Transport System	09-72/12-72	Solution Commercially Available
GLM-50	Catheter Support for Rehabilitation Patients	09-72/03-73	Incorporated into GLM-45
GLM-53	Miniature Angular Accelerometer for Pigeon	05-73/09-73	Not Biomedically Oriented Enough
GLM-54	Miniature Telemetry Transmitter for Pigeon	05-73/09-73	Not Biomedically Oriented Enough
GVA-6	Respiration Monitor	05-70/08-73	Insufficient Progress
HPH-1	Particle Detector Monitor for	11-70/01-73	Insufficient Progress
HPH-2	Helmet and Mask Study	11-70/06-73	Insufficient Progress
HSR-1	Impression Material for Making Pattern of Lower Trunk	04-70/12-72	Investigator Left Institution
HSR-2	Resilient, Breathing Contour Seat Cushion	03-70/12-72	Investigator Left Institution
HSR-6	Sight Switch Operated-Prehension Device	03-72/02-73	Investigator Left Institution
HSR-7	Improved Assist Device Expands Self-Sufficiency Potentials for Quadriplegics	03-72/02-73	Tech.Appl. Evaluation Completed
HUV-20	Perceptual Motor Testing of the Severely Disabled	01-71/01-73	NASA Tech. not cost-effective enough
HUV-22	Automobile Driving Assist for Triplegic	06-71/05-73	Investigator stopped progress after mis-informed by aerospace contractor

No.	Problem Title	Opened/Closed	Remarks
HUV-23	Automatically Operated Magnetic Tape Cassette Recorder	05-72/01-73	Solution Cost Beyond BATEam Resources
LLU-10	Noninvasive Techniques for Measuring Oxygen Content in the Blood	08-70/02-73	Insufficient Progress
LSU-1	Physiological Effects of Motion Sickness	09-72/06-73	Insufficient Progress
LSU-2	Whole Body Radiation Measurement	09-72/06-73	Insufficient Progress
LVA-3	Radioactive Microcell Counting Techniques for Diagnosis & Treatment of Leukemic Disorders	06-70/06-73	Investigator left Institution
LVA-5	Device for Weighing Laboratory Rats	07-70/11-72	Low Priority
LVA-6	Method for Measuring Temperature of Laboratory Rats in Isolation Chambers	07-70/11-72	Low Priority
LVA-7	Method for Acquiring ECG Information from Laboratory Rats in Isolation Chambers	06-70/11-72	Low Priority
LVA-8	Abrasive-Resistant Plastic Material for Use in Trace Element Research Studies	09-72/06-73	Biomedical Community Impact-Commercial Solution identified through NASA
MHB-1	Out-Patient Clinic Computerization for County Hospital	03-71/11-72	Insufficient Progress
MHB-2	Computer Program for Health Care Improvements	03-71/11-72	Insufficient Progress
MHH-1	Rapid Identification of Surgical Instruments	06-72/05-73	Insufficient Progress
MVA-2	Measurement and Recording of Urine Flow	03-71/11-72	Solution Commercially Available
NMA-1	Program to Establish Electrical Safety Standards for Equipment and Instruments Used Around Patients	06-70/05-73	To Broad for BATEam Action

No.	Problem Title	Opened/Closed	Remarks
NMA-3	ECG Cable Take-Ups for a Portable ECG Monitor in an Intensive Care Unit	06-70/11-72	Solution Commercially Available
NMA-10	Video Tape Programming for Speech Therapy	06-70/01-73	Solution Cost Beyond BATEam Resources
NMA-12	Sauna Bath Conditions Monitoring	11-70/11-72	No Applicable NASA Technology
NMV-1	Control System To Permit Quadriplegics to Operate Long Playing Recording Devices	06-72/03-73	Solution Cost Beyond BATEam Resources
NUM-2	Measure Diameter of Femoral Artery by Ultrasonic Pulse-Echo Method	05-72/09-73	Insufficient Problem Progress
OCH-1	Plastic Long Leg Braces for Children	06-71/11-72	Insufficient Progress
OCH-7	Work Space for Upper Extremity Amputee	06-71/11-72	Solution Cost Beyond BATEam Resources
OVA-4	Assessing Sleep Psychophysiology in Extreme Environments	12-70/05-73	Hardware Tech. Appl.
OVA-5	Nonencumbering EEG Electrode Assembly	12-70/09-72	Incorporated into OVA-4
PPR-1	Home Paging System for Reminding Elderly Patients of Medication Times	12-71/05-73	Investigator could not deal with BATEam concept requirements
PVA-3	EEG Analysis Computer Programs	08-70/11-72	Insufficient Progress
PVA-4	EEG Electrode Holders	08-70/11-72	Insufficient Progress
PVA-5	Low Noise EEG Preamplifiers for Clinical Research	08-70/11-72	Insufficient Progress
PVA-6	Bandpass Filtering for EEG Alpha Signals	08-70/11-72	Solution Commercially Available
RNV-34	Pressure Sensitive Device for Use in Tongue Operated Control Systems for Artificial Organs and wheelchairs	09-70/06-73	Final Solution Beyond BATEam Resources
RNV-37	Surgically Implantable Nerve Stimulator	07-71/11-72	Insufficient Progress
RNV-38	Design Techniques for Making DC Motors for Powered Orthotic Devices	09-71/11-72	Solution Cost Beyond BATEam Resources

No.	Problem Title	Opened/Closed	Remarks
RNV-39	Development of Proper Procedures and Observation of Human Subjects in Medical Research	10-71/11-72	Information Tech. Appl.
ROS-1	Constant Velocity Vehicle for Small Laboratory	12-70/12-72	Low Priority
RRC-1	High Energy Cost Exerciser with Ergometric Monitor	01-71/01-73	Insufficient Progress
RRC-2	Accurate Cardiac Telemetry from Active Subjects	01-71/01-73	Tech. Evaluation Completed
RRC-6	Lightweight, Portable Cushion Seat Jack for Weak or Paralyzed Patients	01-71/03-73	Would conflict with ongoing commercial research
RRC-7	Oscilloscope Synchronization for Electromyographics Needle Manipulation	01-71/11-72	Insufficient Progress
RRC-8	Ultra-Thin Electromyographic Needles	01-71/09-73	Hardware Tech. Appl.
RRC-9	Automatic Locking Prosthetic Leg	06-71/12-72	No Applicable NASA Technology
SJH-1	Interfacing Biochemical Autoanalyzers with a Computer	03-70/11-72	Investigator Developed Own Solution
SJH-2	Interface Schematics for Incorporation of Autoanalyzers to a Computer	09-70/11-72	Investigator Developed Own Solution
SLU-1	Elimination of Motion Artifact from EEG Leads in Pedestal Equipped Animals	12-72/06-73	Investigator Dropped Interest
SNM-13	Miniature pH Electrode for Fetus	03-70/01-73	No Applicable NASA Technology
SNM-14	Fetal ECG Telemetry	03-70/01-73	No Applicable NASA Technology
SNM-15	Uterine Pressure Telemetry	03-70/01-73	No Applicable NASA Technology
SNM-24	Brain Resistance and Impedance Changes Under Anesthesia	04-71/11-72	Insufficient Progress
SNM-25	Development of an in vivo blood glucose, pH , and pO <sub>2</sub> analyzer	03-72/09-73	Insufficient Progress

No.	Problem Title	Opened/Closed	Remarks
SNM-26	Monitoring of Pelvic Pressure of Women During Labor	06-72/01-73	Hardware Tech. Appl.
SWC-6	Apparatus for Micropuncture of Pancreatic Gland	04-70/11-72	Insufficient Progress
SWC-13	ECG Data Compression Techniques	01-71/11-72	Insufficient Progress
SWR-1	Custom Fitted Composite Leg	02-72/08-73	Hardware Tech. Appl.
TAM-1	Direct Skeletal Attachment of Prosthetic Devices	11-70/11-72	Insufficient Progress
TAR-1	Epileptic Seizure Warning Device	08-71/11-72	No Applicable NASA Technology
TCB-1	Remotely Activated Switch for Electrically Operated Saw	05-71/11-72	Technology Appl. Eval. Completed
TCB-2	Blind Person Guidance Detector of Impregnated Paint or Wire Boundary Marker	05-71/01-73	Technology Appl. Eval. Completed
TCB-4	Nonmagnetic Homing Device for Blind Persons	05-71/11-72	No Applicable NASA Technology
TCB-5	Acoustic Signal to Alert Blind Typist of Approaching End of Page	05-71/11-72	Solution Commercially Available
TCB-16	New Type of Tracking Cane for the Blind	11-71/09-72	Technology Appl. Eval. Completed
TCB-17	Acoustic Signal to Alert Blind Persons to Obstacles between the Waist and Head	04-72/02-73	Solution Commercially Available
TCB-18	Permanent Reflective Coating for Use on Canes for the Blind	04-72/05-73	Biomedical Community Impact-Commercial Solution Identified through NASA
TCB-19	Navigation Assistance to Keep Blind on a Set Direction of Travel	04-72/03-73	No Applicable NASA Technology
TCD-1	Portable Sound Meter for Use by the Deaf	03-71/01-73	Technology Appl. Eval. Completed
TCD-2	Warning System for Use by the Deaf	03-71/01-73	Technology Appl. Eval. Completed

No.	Problem Title	Opened/Closed	Remarks
TCD-3	Portable Substitute for Door/ Telephone Bell for the Deaf	03-71/01-73	Technology Appl. Eval. Completed
TCD-5	Speech Analyzer	04-71/01-73	Solution Cost Beyond BATEam Resources
TCD-9	Portable Amplifier System for Patient with Partially Inac- tivated Vocal Cords	10-71/01-73	Hardware Technology Appl.
TCH-1	Quantification of Biochemical Changes in Striated Muscle Due to Inactivity	11-70/11-72	No Applicable NASA Technology
TCM-3	Peak Detector for Signal Condi- tioning of Blood in Basic Medical Research	04-70/03-73	Investigator Developed Own Solution
TPR-1	Electro-Sleep Electrodes	03-71/02-73	Insufficient Progress
TPR-2	Device to Correct Foot Pronation	09-71/03-73	Insufficient Progress
TTU-2	Bibliography on NASA's Involvement in Attention and Vigilance Monitoring	10-72/04-73	Information Tech. Appl.
TVA-2	Portable Heart Rate Indicator for Active Patients	04-72/12-72	Hardware Tech. Appl.
UAD-1	Tooth Movement Sensor	09-71/11-72	Low Priority
UAD-2	Tooth Position Within the Socket	09-71/11-72	Low Priority
UAD-3	Determination of Tooth Vitality	09-71/02-73	NASA Solution not cost- effective enough
UAD-4	Tooth Vitality Measured by Nerve Condition	09-71/02-73	No Applicable NASA Technology
UAD-5	Preparation of Dental Material Samples for Microscopic Analysis	09-71/11-72	Low Priority
UAD-6	Microhardness Analysis of Tooth Enamel	09-71/11-72	Low Priority
UAM-1	Capacitative ECG Electrodes	05-70/02-73	Insufficient Progress
UAM-2	Heart Sounds Telemetry	05-70/02-73	Investigator did not wish to participate in proper evaluation
UAM-3	Implantation Techniques for Chronic Measurements of Physiological Data	10-70/11-72	Insufficient Progress



No.	Problem Title	Opened/Closed	Remarks
UAM-5	Study of Cell Fluorescence by TV Under Low Light Intensity Conditions	10-70/11-72	Solution Cost Beyond BATEam Resources
UAM-8	Electro-Optical Isolator	10-70/02-73	Technology Evaluation Completed
UAM-12	Cardiovascular Dynamics Models	12-70/11-72	Insufficient Progress
UAM-13	Flexible Oral Transducer Matrix	09-71/06-73	Insufficient Progress
UAM-18	AK Prosthesis Fabricated from Composite Materials	01-72/10-72	Insufficient Progress
UFM-6	Xeroradiography of Mammary Glands for Cancer Detection and Multiphasic Health Screening	05-70/01-73	Insufficient Progress
UFM-7	Methods for Computer Analysis of EEG for Health Care Cost Reduction	05-70/08-73	Information Technology Application
UOF-2	Low-Level Non-Invasive Blood Pressure Measurement	06-71/07-73	Investigator used NASA Technology, but did not wish to report his work
UOF-3	Detection of Schools of Fish in Pollutant Studies	03-72/11-72	Not biomedically oriented
UOF-4	A Method for Determining Blood Coagulation by Phonocardiography	03-72/09-73	NASA hardware not available for eval.
UOW-1	Improved Eye Switch Control for Use by Totally Paralyzed Cerebral Palsy Patients	03-72/11-72	Insufficient Progress
USC-9	Methods for Obtaining Otological Response in Experimental Animals	08-70/11-72	Insufficient Progress
UTH-1	A Tactile Projector for Teaching Blind Students	01-72/02-73	Investigator Developed Own Solution
UTM-1	Physiologic Data Handling-Systems Approach	02-70/12-73	Insufficient Progress
UTM-24	Photo-Etched Form to Cast Artificial Kidney Matrix	12-70/11-72	Insufficient Progress
UTM-25	Ionizing Radiation Detection of Thrombogenesis	12-70/06-73	No Applicable NASA Technology
UTM-27	Miniature Mosiac TV Camera	12-70/12-72	Solution Cost Beyond BATEam Resources

No.	Problem Title	Opened/Closed	Remarks
UTM-30	Biocompatible Bone Interface for Prosthesis	04-71/12-72	Insufficient Progress
UTM-31	Plastic Prosthetic Materials	04-71/06-73	Insufficient Progress
UTM-32	Improved Design for Foot Supports	04-71/06-73	Insufficient Progress
UTM-33	Form-Fitted Foot Pad Brace	04-71/12-72	Insufficient Progress
UTM-34	Lining Absorbs Pressure and Friction Forces	04-71/11-72	Insufficient Progress
UTM-35	Lightweight Long Leg Braces	04-71/11-72	Insufficient Progress
UTM-36	Artificial Heart Transducer	08-71/11-72	Solution Commercially Available
UTM-37	Butt-Welded Fine Gauge Wire	08-71/01-73	Tech.Appl.Eval.Completed, but investigator did not wish to pursue needed modification
UTM-40	Detecting Oxygen Toxicity in the Lung	11-72/09-73	Information Technology Application
UTM-44	Detection/Measurement of Microbubbles or Microbubbles in the Blood	11-72/09-73	Information Technology Application
VAL-3	Computer Applications in Hospitals-Practical Criteria Collation	04-73/08-73	Information Technology Application
WLH-2	Device to Clinically Evaluate Nasal Airway Obstructions	08-71/01-73	Technology Appl. Eval. Completed
WLH-3	Elasticity in Long Bones to Determine Optimum Fracture Knitting Condition	12-71/12-72	No Applicable NASA Technology
WLH-4	Myoelectric Powered Prosthesis	12-71/12-72	Solution Cost Beyond BATEam Resources
WMC-1	Plethysmographic Data Interface System	10-72/06-73	Information Technology Application

### 3.3 Search Activities Summaries

Below is a list of computer searches performed during the reporting period. They are listed numerically by the NASA STIF record number because all search reports could be duplicated and updated if the subject material is of interest for the BATEam or prospective investigators.

NASA STIF (RECON) No.	Citations	Subject
T0077	317	"Computer Analysis of EEG"
T0593	96	"Abrasive Resistant Plastic Materials"
T0594	238	"Tactile Discrimination"
T0595	317	"Measurement of Heart Stress"
T0596	39	"Electronic Aids to Handicapped"
T0609	69	"Microelectrode Stimulation of the Brain"
T0612	142	"Motion Sickness Drugs"
T0613	250	"Radiation Absorption Measurement Technology"
T0614	202	"Methodology and Techniques of Automation of Plethysmographic or Cardiovascular Data Analysis"
T0616	113	"Evaluation of Psychomotor Skills"
T0618	463	"Oxygen Toxicity"
T0619	22	"Materials Compatibility for Prostheses"
T0621	80	"Blood Vessel Wall Measurement"
T0622	225	"Surface Roughness Analysis Under Electron Micrography"
T0636	24	"Urine Collection"
T0637	16	"Tubing Clamps"
T0638	56	"Physiology of Venous Pressure and Pooling"
T639	62	"Inflatable Structures and Cushions"

NASA STIF (RECON) No. Citations Subject		
T0641	228	"Radiation Resistant Materials"
T0642	322	"Hypothermia Techniques, Effects and Use in Chemotherapy"
T0654	130	"Self-Injurious Behavior"
T0655	136	"Nocturnal Activity" (Sleep and Behavioral Patterns)
T0658	262	"Portable Oxygen Supplies"
T0667	119	"pH or Acidity Sensing by Remote Means"
T0669	110	"Arc or Angle Measurement"
T0671	537	"Vigilance or Attention Monitoring"
T0681	192	"Processing and Display of Acoustic Speech Signals"
T0689	140	"Psychomotor Performance Related to Biocontrol Systems"
T692	197	"Nitrogen Molecule Effect of Physiological Functions"
T699	189	"Feedback for Biological Functions"
T700	48	"Nonlinear Equations and Nonlinear Systems for Biological Functions"
T701	774	"Bionics (Biological Models)"
T703	205	"Non Contact Electrocardiogram Monitoring"
T713	48	"Effect of Sensory Deprivation on Learning Process"
T727	69	"Electrostatic Burn Treatment"
T728	123	"Immunological Response of Leukocytes"
T729	57	"Bioinstrumentation for Respiratory Functions During Studies of Vibration Effects"
T730	686	"Computer Applications in Medicine and Health"

NASA STIF

(RECON) No. Citations

Subject

T740

340

"Impact Acceleration Stress on Organs"

#### 4.0 APPLICATIONS ENGINEERING PROGRAM

##### 4.1 Applications Engineering Projects Completed

Below is a list of applications engineering projects completed during the reporting period at Southwest Research Institute and at NASA Centers. See the Technology Application Reports for complete summaries.

No.	Problem Title	Date Opened/Closed
<u>Projects completed at Southwest Research Institute:</u>		
AEB-1	Method for Identifying Denominations of Paper Money	06-72/03-73
AEB-2	Measurement of Physiologic Stress Parameters	06-72/01-73
AEB-4	Apparatus for Measuring Tactile Spatial Separation	06-72/09-73
BVA-4	Portable ECG Telemetry Receiver and Tape Recorder	04-70/01-73
CRH-8	Weight Shift Alarm for Brain Damaged and Paraplegic Persons	03-73/07-73
GLM-32	ECG Preamplifier for Home Tape Recorder (Extensive Modification Work)	04-70/08-73
SNM-26	Monitoring of Pelvic Pressure of Women in Labor	06-72/01-73
SWR-1	Custom Fitted Composite Leg Braces	02-72/01-73
TCD-9	Portable Amplifier System for Patient with Partially Inactivated Vocal Cords	10-71/01-73
TVA-2	Portable Heart Rate Indicator for Active Patients	04-72/12-72

##### Projects Completed at NASA Centers:

AEB-3	Light Sensitive Vocational Rehabilitation Aid (LANGLEY RESEARCH CENTER)	06-72/09-73
RRC-8	Ultra-Thin Electromyographic Needles (LANGLEY RESEARCH CENTER)	01-71/09-73

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## 4.2 Applications Engineering Projects in Progress

Below is a list and status report of applications engineering projects in progress at contract termination.

### Projects in Progress at Southwest Research Institute:

#### GLM-35      BETA RADIATION CATHETER PROBE

Work being done at: SwRI

Key Personnel: Charles Laenger, Robert Wilbur

NASA Technology: B66-10252

Current delivery schedule: Not projectable

Status: Still waiting for funding approval from NASA Headquarters on extensive follow-up fabrication and testing project.

#### MSC-1      PORTABLE SCALP COOLING DEVICE (Chemotherapy)

Work being done at: (Proposed, see status)

Key personnel: Sam McFarland

NASA Technology: Ames developed technology for liquid cooled garment systems

Current delivery schedule: Not projectable

Status: Per tentative agreement with Bob Zimmerman at NASA Headquarters, Aerotherm and LTV (NASA contractors for the Ames work) are planning to submit bids to TU for proposal to handle specific problem solution.

#### TCB-20      DEVICE TO ENABLE BLIND DIABETICS TO SELF-ASSESS URINALYSIS TESTS

Work being done at: SwRI

Key personnel: Chuck Dreyer, Robert Wilbur

NASA Technology: B69-10301

Current delivery schedule: Dec., 1973 (pending contract renewal schedule)

Status: Initial feasibility design in progress also utilizing concept suggestions from David Winslow at Marshall Space Flight Center.

TTU-3 RATE MONITOR FOR SELF-INJURIOUS BEHAVIOR

Work being done at: SwRI  
Key personnel: Chuck Dreyer  
NASA Technology: B71-10437  
Current delivery schedule: Fall, 1973 (pending contract renewal schedule)  
Status: Receiver unit is complete. Preliminary design of transmitter is complete. Soft-caps in fabrication.

TTU-4 NOCTURNAL ACTIVITY MONITOR

Work being done at: SwRI  
Key personnel: Chuck Dreyer  
NASA Technology: B70-10638, B72-10452  
Current delivery schedule: Dec., 1973 (pending contract renewal schedule)  
Status: Work is in preliminary design stages. Visit with Ames personnel confirmed feasibility approach.

UAD-7 TELEMETRY OF ORAL pH FOR DETERMINATION OF LINKAGE TO CAVITY FORMATION

Work being done at: SwRI  
Key personnel: Chuck Dreyer  
NASA Technology: Ames pH sensor and telemetry technology  
Current delivery schedule: Not projectable  
Status: Investigator has been extremely helpful in providing exact needed specifications and has offered to visit SwRI and/or provide a plaster cast of the oral bridge for fitting (needed device will be implanted in a tooth socket). Team has received replies from suggestions of Ames personnel (Case Western Reserve) with offer to help on the pH sensor. Telemetry is essentially solved. Because of necessary microminiaturization, it might be mandatory to work with a NASA Center on implementation of this project.

UTM-38 IMPROVED URETHRAL VALVE FOR NONSURGICAL IMPLANTATION

Work being done at: SwRI  
Key personnel: Sam McFarland  
NASA Technology: Basic NASA technology in biocompatible materials for device fabrication  
Current delivery schedule: Dec., 1973 (pending contract renewal schedule)  
Status: Investigator has provided us with a design concept. McFarland has completed preliminary design drawings. Several prototypes will be built and animal



testing will be carried on at SwRI after fabrication. Bob Zimmerman has requested that we make several samples available after animal testing for several large nationwide facilities extremely interested in the concept.

UTM-39      MULTI-CHANNELED HYPOTHERMIA BLANKET FOR HEART SURGERY

Work being done at: SwRI

Key personnel: Sam McFarland

NASA Technology: Basic NASA technology in special biocompatible materials and sealing techniques

Current delivery schedule: Initial prototype delivered.

Status: Although a prototype has been delivered, the seal was not adequate. Investigator is very enthusiastic. As soon as there is time and funding, the design seems to be workable, so we will fabricate a few more, utilizing some helpful sealing technique suggestions provided by Ames personnel.

Projects in Progress at NASA Centers:

AEB-5      MOTION SENSOR TO PROVIDE BIOFEEDBACK TO BLIND PERSONS  
UNAWARE OF INVOLUNTARY MOVEMENTS

Work being done at: JSC

Key personnel: Dr. Sam L. Pool, John Sigmon

NASA Technology: Miniature accelerometers and Boeing mercury switches

Current delivery schedule: Dec., 1973

Status: Information on the switches has been obtained and personnel at JSC are determining suitability. Some conversations have also been held with investigator by JSC personnel on details for special accelerometer development.

AVA-2

Work being done at: Goddard

Key personnel: Wayne Chen (Robert Wilbur, SwRI)

NASA Technology: Goddard's technology development on an "Improved Arterial Pulse Pressure Transducer."

Current delivery schedule: Several units are complete and are in evaluation for Goddard at the VA Hospital in Washington, D.C. SwRI hopes to obtain one of the units for our investigator's evaluation sometime this fall.

Status: Per above.

## CHS-10 HEARING AID MALFUNCTION ALARM SYSTEM

Work being done at: JSC

Key personnel: Dr. Sam L. Pool, John Sigmon

NASA Technology: Specialized alarm circuitry being developed at JSC.

Current delivery schedule: Dec., 1973 (approx)

Status: Further specifications are due from investigator.

## SWC-2 CORTICAL AUDIOMETRY MEASUREMENTS

Work being done at: MSFC

Key personnel: Stephen Graff, Robert Allen

NASA Technology: MSFC developed hybrid microcircuit techniques

Current delivery schedule: Fall, 1973 (approx)

Status: HA dice operational amplifiers were due around 18th July at which time final fabrication was due.

## TCD-4 FLASHER WARNING ALERT FOR DEAF DRIVERS

Work being done at: JSC

Key personnel: Dr. Sam L. Pool, John Sigmon

NASA Technology: Basic aerospace bandpass filtering techniques and amplifier technology suggested by David Winslow at MSFC.

Current delivery schedule: Fall, 1973 (approx)

Status: Preliminary fabrication of prototype in initial stages.

## TTU-5 CONTROL OF HIGH BLOOD PRESSURE BY BIOFEEDBACK TECHNIQUES

Work being done at: JSC

Key personnel: Dr. Sam L. Pool, John Sigmon

NASA Technology: Automatic cuff inflator pressure measurement device developed at JSC.

Current delivery schedule: Dec., 1973 (approx)

Status: JSC prototype device is on hand to modify.

Investigator provided exact specifications and SwRI documented needed modifications. JSC to make decision on follow-through.

## UAM-14 SELF-PROPELLED METABOLIC ANALYZER CART

Work being done at: MSFC

Key personnel: Juan Pizarro II

NASA Technology: Based on the metabolic analyzer developed for Skylab

Current delivery schedule: Fall, 1973 (approx)

Status: Final completion stages in progress

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APPENDICES

## APPENDIX A

## Commercially Available Versions of Technology Applications

The AEB-1 problem in this report is commercially available as the "Paper Money Identifier" from:

APPLIED REHABILITATION SYSTEMS  
3902 Idlewild  
Austin, Texas 78731  
(512) 459-7739

Cost: \$149.50 plus tax (Brochure available)

A version of the AEB-2 and TVA-2 problems in this report is available as the "Medi-Mini-Monitor" ECG telemetry system from:

Modern Medical Methods, Inc.  
P. O. Box 4824, Wonderland Post Office  
San Antonio, Texas 78285  
(512) 344-7572

Cost: Write or call for details. Brochure available.

The following commercially available items were developed as prototypes in the technology application program in previous contract years and until now have been unavailable.

The product development of the original HSR-7 problem is on the market as the "Multi-Medassist-Model," which is a ten channel control system designed especially for those persons whose daily living activities have been restricted by disease, accident, or natural calamity. Even quadriplegics can operate up to ten different appliances (televisions, lights, radios, air conditioners, etc.) by utilizing a choice of breath switches, eye switches, or pneumatic switches. The unit is completely portable and is compatible with existing electrical outlets. Price of the device is subject to individual needs and number of channels and switching configurations desired. For more details, please contact:

Modern Medical Methods, Inc.  
P. O. Box 4824, Wonderland Station  
San Antonio, Texas 78285  
(512) 344-7572

Another previous problem, CMR-3, has brought about the availability of the "Vitasign Attendant Monitor" with Isolator, an ECG/Respiration Monitor and Alarm System. This device brings vital signs constant monitoring capabilities out of the intensive care facilities where special power installations are required. This completely portable unit plugs directly into existing nurse call outlets, uses existing wall outlets for power and has an alarm system that utilizes the existing nurse call system. Through three properly placed electrodes, the unit provides constant monitoring of ECG and respiration rate. Color-coded visual display is constant, and oscilloscope and/or strip chart recording can be employed. Meter settings for ECG and respiration rate are adjusted when the unit is turned on. A change in the normal respiratory cycle of the subject or a loss or severe change in the ECG signal will trigger the alarm light on the unit and activate a signal at the central call station so that immediate corrective action can be taken. For cost and information details, please contact:

Modern Medical Methods, Inc.  
P. O. Box 4824, Wonderland Station  
San Antonio, Texas 78285

Other devices are being considered for manufacture at the present time. If anyone reading this report is interested in inquiring about acquiring the information necessary to become involved in the manufacture of these NASA developed items, you are encouraged to contact any of the team members mentioned in this report, or call NASA Headquarters, Office of Technology Utilization, Code KT, Washington, D.C. 20056, (202) 755-3794.